Project Proposal: How Can Wastewater Testing be Used to Monitor Drug Consumption?

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DATA 601: Working with Data and Visualization

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FALL 2024

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Introduction

Drug consumption monitoring within the population is imperative for assessing the public health system. Markedly, such monitoring enables officials to address ongoing drug-related crises, while also forecasting future surges (EUDA, 2024). Considering that the use of illegal/unprescribed narcotics, stimulants, and hallucinogens generally goes unreported, an effective method can be used to monitor the concentration of drug metabolites within the wastewater (EUDA, 2024). Drug metabolites are the breakdown products of the parent drug formed following metabolization, which are then typically excreted out of the body (DNA Legal, 2021). Therefore, its presence in wastewater can predict parent drug use within the population (Yi et al., 2023).

Given the potency of using drug metabolites to monitor drug usage, our project will investigate a dataset, produced by Statistics Canada (2024), that measures the detection of drug metabolites in wastewater within seven selected Canadian cities. The ability to monitor drug consumption is a significant and necessary step towards addressing unseen drug issues (EUDA, 2024). We will categorize the drugs measured in the dataset into two categories: Prescribed and Unprescribed. Drugs that constitute as Prescribed will include Cannabis, Codeine, Fentanyl, Methadone, Morphine, and Oxycodone, as these are all classes of drugs that are typically prescribed as high-power painkillers (CCSA, 2024). Drugs that constitute as Unprescribed will include Amphetamine, Cocaine, Ecstasy, and Methamphetamine, as these are classified as illegal substances **(RCMP, 2024).** These categorizations will shed light on whether overall drug consumption is mostly composed of illegal or legal drug usage. It is important to note that this dataset can only be used as a prediction, which limits us in our research (Perez-Iracheta & Oliver, 2024). In simpler terms, although there is a correlation between the level of drug detection in the wastewater and the consumption of the parent drug within the city, we cannot deduce causation between the two. We must consider other factors that can alter these results, such as the dumping of drugs (Perez-Iracheta & Oliver, 2024). Our project will provide valuable support to other initiatives led by Statistics Canada, particularly to those focused on the city's economic and social statistics including public health and lifestyle conditions (Statistics Canada, 2024).

Dataset

The data on "Drug Metabolites in Wastewater in select Canadian Cities, by month, 2022 to 2023" focuses on the detection amounts of different drug metabolites in the wastewater of several cities in Canada (Statistics Canada, 2024). The seven cities included in this study are Halifax, Montreal, Toronto, Prince Albert, Saskatoon, Edmonton, and

Vancouver. This data will be used to estimate the levels of drug consumption by detecting various drug metabolites found in wastewaters. It is important to note that the values presented in the dataset are estimates of the amount of drug metabolites excreted into the wastewater, so it does not directly create a causal link to the total consumption levels of the specific drug. However, inferences and predictions of consumption levels can still be made. The dataset is structured and in tabular format consisting of 1111 rows and 13 columns (Statistics Canada, 2024).

The dataset was completed by collecting wastewater samples from wastewater treatment plants in each city. The number of treatment plants in each city is as follows: Halifax (3), Montreal (2), Toronto (4), Prince Albert (1), Saskatoon (1), Edmonton (1) and Vancouver (5) (Statistics Canada, 2024). Samples were collected for seven consecutive days, every 24 hours, starting every second Monday of the month for the year 2022 and every second Wednesday for the year 2023. The collected water samples were then analyzed by mass spectrometry at the Health Canada's Regulatory Operations Enforcement Branch to measure the concentrations of drug metabolites in daily loads per capita. This is done by calculating the total volume of influent arriving at each treatment plant on the day of sampling and the estimated population in the sewer shed (based on 2021 Statistics Canada Census Population).

Guiding Questions

1. What is the level of the drug metabolites detected in the wastewater of each city in a span of 17 months?

   Monitoring the levels of drug metabolites in wastewater and analyzing monthly patterns can help cities identify periods of increased drug activity and understand seasonal variations in drug usage. There may be a correlation between weather and drug consumption, which could help the city to prepare for potential increases in overdoses. For example, the city can schedule more ambulances and EMTs, as well as promote the distribution and use of naloxone kits during a specific time of year if there is a spike in Unprescribed drug metabolites.

1. Which city has the highest detection of drug metabolites?

   Although drug metabolites can be found in almost every city, it is important to be aware of the magnitude of the level of drugs detected in our wastewaters for many reasons. Observing the magnitude helps city officials and federal agencies plan financially, as well as forecast the demand for social services and resources.

2. Unprescribed vs. Prescribed: Within our selected city, is the estimated consumption mostly caused by Prescribed or Unprescribed drugs? What is the overall leading drug?

   Differentiating between prescribed and unprescribed drug metabolites is extremely important to avoid making assumptions regarding illicit drug use within the observed data. Dividing the data into Unprescribed versus Prescribed can help the city investigate underlying drug issues that they are unaware of; whether it's caused by doctors overprescribing legal drugs to their patients or potentially warning the city's police of a potential distributor of a specific type of illicit drug.

3. What is the predicted drug detection trend in the upcoming X months? Which city is predicted to have the most consumption?

   Answering this question can assist both the provincial and federal governments in determining where to allocate resources. These resources can be financial or to prepare for an increase in social programs or services. For example, if there is a predicted growth in illicit drug metabolites then governments can forecast staffing needs, such as police and healthcare professionals to respond to this matter.

Tasks

Data Cleaning: The dataset contains no null values, but we anticipate potential outliers that will require handling.

Data Filtering: The dataset can be filtered based on Cities and Drug Types, which can be classified as Prescribed or Unprescribed drugs, and the months in our dataset can be grouped into seasons to analyze seasonal variations.

Data Transformation: Regression analysis can be done using different transformation techniques such as normalization, standardization, or the minimum and maximum scaler can be applied to improve model accuracy.

Data Visualization: We will employ various methods to aid in the data visualization component of our project.

- **Line Chart:** To analyze trends and fluctuations in drug concentration over time using regression analysis for prediction and comparison with historical data.
- **Heat Map:** To observe the detected drug metabolites, both Prescribed and Unprescribed, across the seven selected cities on the map of Canada. The city with the largest detection levels will have the darkest color and/or largest ring.
- **Box Plots:** Present a monthly summary of the drug concentration distribution, highlighting the main trends and the outliers.
- **Bar Graph:** To display comparisons of Prescribed vs. Unprescribed Drugs in the top three cities displaying highest overall drug metabolite detected in wastewater.
- **Scatter Plot: To visualize the drug metabolite concentration levels in** milligrams per one thousand people per day (mg/1000 people/day) **over a 17-month period for each city.** The legend will show the different types of drugs.

Python Libraries:

- NumPy – For handling series data and in case of any numerical computations.
- Pandas – For exploratory data analysis tasks.
- Seaborn – For heat maps and box plots.
- Matplotlib – Data visualization like line charts and bar graphs.
- Scikit- Learn – For regression analysis.

Software/Environment:

- Jupyter Notebook: For our project we will use Jupyter Notebook but will be uploading it on GitHub.
- Git Hub: We plan to make a private organization on GitHub where we all can collaborate on the code.

References:

CCSA (2024) *Opioids*, *Canadian Centre on Substance Use and Addiction*. Available at: https://www.ccsa.ca/opioids#:~:text=Common%20opioid%20pharmaceutical%20medications%2C%20such,primarily%20used%20to%20treat%20pain. (Accessed: 22 September 2024).

DNA Legal (2024) *DNA Drug testing: Drug metabolites (part 1)*. Available at: https://www.dnalegal.com/blog/drug-testing-drug-metabolites-part-1 (Accessed: 20 September 2024).

European Union Drug Agency (2024) *Wastewater analysis and drugs - A European multi-city study*. Available at: https://www.euda.europa.eu/publications/html/pods/waste-water-analysis_en (Accessed: 22 September 2024).

Perez-Iracheta, C. and Oliver, L. (2024) *Level of Drugs in the Wastewater of Canadian Cities*, *Government of Canada*, *Statistics Canada*. Available at: https://www150.statcan.gc.ca/n1/en/catalogue/71-607-X2024021 (Accessed: 19 September 2024)

Royal Canadian Mounted Police (2024) *Substances: Controlled and illegal*, *Royal Canadian Mounted Police*. Available at: https://rcmp.ca/en/drugs/substances-controlled-and-illegal (Accessed: 22 September 2024).

Statistics Canada (2024). Table 13-10-0871-01 Drug metabolites in wastewater in select Canadian cities, by month, 2022 to 2023 (Accessed: 19 September 2024)

Yi, R., Zeng, T., Chen, J., Liu, D., Yang, X., Zhao, M., & Zhou, Z. (2023). Wastewater-based epidemiology: Assessing illicit drug usage and impact through an innovative approach. *Water*, *15*(23), 4192. https://doi.org/10.3390/w15234192