UPDATED

THIS REPORT HAS BEEN UPDATED TO INCLUDE IMPROVED STATISTICAL MODELS TO PROVIDE A MORE NUANCED INTERPRETATION OF THE FACTORS DRIVING OUR DATA. AMONG OTHER THINGS WE'VE CHANGED OUR REGRESSION MODEL TO CONTROL FOR HIGH VOLATILITY IN THE DRUG SUPPLY –PARTICULARLY IN PHILADELPHIA, WHICH ACCOUNTS FOR MORE THAN 60 PERCENT OF OUR DATASET. WHILE OUR FINDINGS ARE LARGELY CONSISTENT WITH AN EARLIER VERSION OF THIS REPORT WE FEEL MORE CONFIDENT IN OUR ANALYSIS. THANKS ARE DUE TO DR. NABARUN DASGUPTA, FROM UNC'S OPIOID DATA LAB, FOR HIS GUIDANCE



Quantitative Trend Analysis (2023-2025)

The year 2023 ushered in fundamental changes to the illicit drug supply in the communities monitored by PA GROUNDHOGS. In February, we covered compositional changes to the illicit opioid supply with our trailblazing "Adulterants" report. That report shed light on the presence of new adulterants [tranquilizers], cutting agents [local anesthetics], and what our chemists believe to be new fentanyl precursors/intermediaries [BTMPS] to the dope supply in Pennsylvania and New Jersey. Thanks to the tireless work of our partners at the Center for Forensic Science, Research & Education (CFSRE) our data has helped inform the harm reduction community and clinicians about new drug-related adverse events and dangerous new side effects of withdrawal. Our work helped expose the extent of medetomidine in the illicit fentanyl supply, and researchers in Philadelphia and Pittsburgh relied on our data to publish reports on the potent new alpha 2 agonist that has been complicating withdrawal efforts since it first appeared alongside fentanyl in April 2024. This research was published by the Centers for Disease Control & Prevention (CDC) and encompasses much of what we know about the extent of medetomidine adulteration and the potentially life threatening side effects of sudden discontinuation of use.

The current Quantitative Trend Analysis is a follow up to PA GROUNDHOGS' Adulterants report and presents an analysis of Drug Purity Trends for four of the nine substances PA Groundhogs currently quantifies: **fentanyl**, **methamphetamine**, **cocaine** and **xylazine**. The report covers the period from January 2023 through May 2025, and to our knowledge is the only report demonstrating trendlines in drug purity published by a US-based community drug checking organization.

We have also analyzed more granularity the introduction of medetomidine to the opioid supply, its association with xylazine scheduling and proportional ratios of medetomidine compared to the amount of fentanyl in 292 dope samples obtained since we first discovered the adulterant in the Pittsburgh and Philadelphia drug supply in April 2024. This represents the first semi-quantitative data on the amount of medetomidine being cut with fentanyl. It's also the strongest empirical evidence we have showing a strong direct correlation between the scheduling of xylazine in Pennsylvania and the increase of medetomidine.

As the only community-based drug checking program in the US conducting lab-based quantitative analysis, PAG is able to observe and rapidly identify fluctuations in the purity of individual components in submitted drug samples. We felt it was critical to share this data with the community of people who use drugs and other stakeholders.

***Methodology*:**
Chemists, toxicologists and pharmacologists at the CFSRE conduct quantitative analysis using GC-MS and LC-QTOF-MS to determine the amount of an individual substance within a small sub-sampling of drug material (usually 3-5mg). This is used to calculate the percent of the drug (in its base form) contained within the sample. This calculation is known as mass-fraction, or mass-percent.

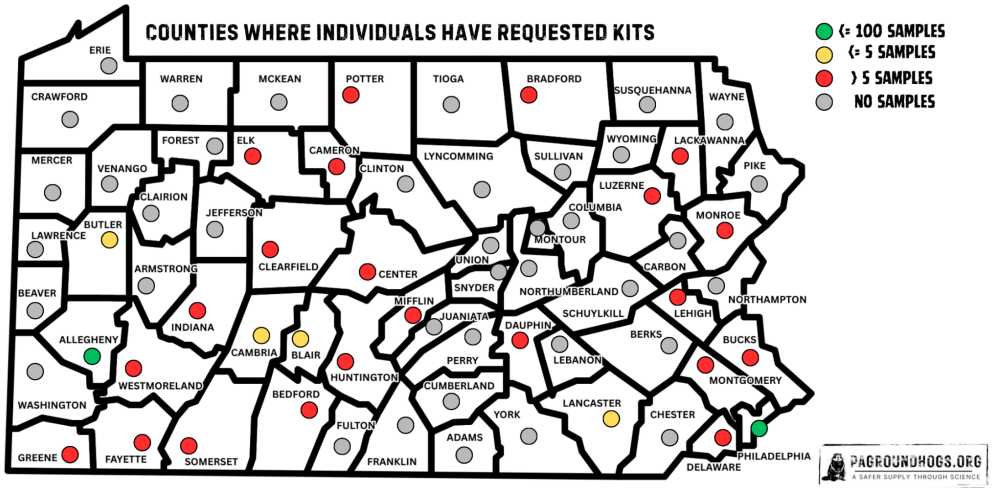
For the current report, PAG analysts began by outputting sample purity data from our database, using artificial intelligence to pull appropriate fields while controlling for anomalies. We used LOESS regression and Spline regression to run longitudinal analysis from January 2023 through February 2025, factoring in market volatility and external events that we believe may have influenced our findings. Finally we ran our results through several validity tests to ensure statistical significance and if necessary contacted human sources to help make sense of our findings.

Limitations:
Our quantitative summaries are calculated using a small sub-sample of the entire drug material. Since people who use illicit opioids typically measure their dosage in “bags,” and bag weights vary even when they come from the same source, it’s difficult to determine with precision how many total milligrams of fentanyl (or a particular cut) an individual may be consuming. Likewise, there’s no way to ascertain if a sample contains hotspots due to inadequate milling. We feel it is important to note these limitations as to emphasize that there are no certainties in an ever evolving unregulated market. As with all areas of scientific research, drug checking is an evolving field. However, PAG and its partners at the CFSRE are diligent in their testing and analysis, and when possible we’ve relied on human intelligence from sources in the communities we serve to fill in the gaps that numbers alone do not adequately explain.

Despite these limitations, quantitative analysis is critical for revealing the trends in longitudinal data on drug purity to identify the impact of new psychoactive substances, public policy and geo-politics on the drug supply.h

Where our data comes from:

As the below map reflects, individuals or organizations from every county in Pennsylvania have ordered and received our mail-in drug checking kits, however many are still unrepresented in our dataset. This is particularly the case in rural counties. In 2025 PAG hired a rural engagement liaison who has been visiting stakeholders in Pennsylvania's rural counties to gain insight into the unique challenges they face, provide guidance on PA's drug checking laws and familiarize them with the GROUNDHOGS organization.



Between January 2023 and May 2025 PA GROUNDHOGS and the CFSRE analyzed 1,038 drug samples. Currently, PAG's dataset remains heavily skewed toward urban communities, with Philadelphia County accounting for 67% of our samples. Allegheny County accounts for 12%. Rounding out our top five counties with quantitative data are Blair County, PA; Lancaster County, PA; and Cambria County, PA. Outside of Pennsylvania, 65 samples were submitted by our partner organization NJ GROUNDHOGS, based in Mercer County. A small number of samples are also included from North Carolina, West Virginia, Michigan and New York.

Key Takeaways:

After running multiple different analyses on our quantitative data PAG has determined that:

1.) **Methamphetamine**, **fentanyl**, and **xylazine** have all experienced **statistically significant declines** in reported average purity since 2023. Xylazine is the most pronounced, as the adulterant has been nearly replaced by medetomidine.. Fentanyl purity in our sample set declined from an average of 14% in 2023 to 7% by the end of 2024. Methamphetamine purityt declined gradually, but steadily, dropping from an average purity of 84% in early 2023 to 73% by 2025.
2.) **Cocaine,** a highly volatile drug, saw a wide variation in purity, ranging from samples above 90% to single digits. We attempted to account for this volatility in our analysis below, but we emphasize that highly volatile are unpredictable and present increased risk to consumers
3.) Pennsylvania's drug market is highly volatile with purity sometimes rising and falling by wide margins month-to-month. High volatility reflects inconsistency in the drug supply and may signal:
    - Multiple supply sources with different cutting practices.
    - Fluctuations in the availability of pure drug material or adulterants.
    - Instability in local drug markets (e.g., raids, seizures, or distribution changes).
    - Variability in our own dataset. For instance, cocaine is a drug that crosses demographic lines, from the party drug scene–where we believe it is found in higher purity to the street drug markets where we find it in lower purity.

Market volatility in illicit drug purity — especially when **strength, composition, or adulterants change unpredictably**— has significant consequences for **consumer safety**. Market volatility creates a minefield for drug users, even those who use cautiously. It undermines harm reduction, increases overdose risk, and complicates medical response — all while staying invisible to the untrained eye.

High Volatility + High Purity = Increased Risk

Months with **both high average purity and high volatility** are especially dangerous. Outreach teams and public health officials should consider:

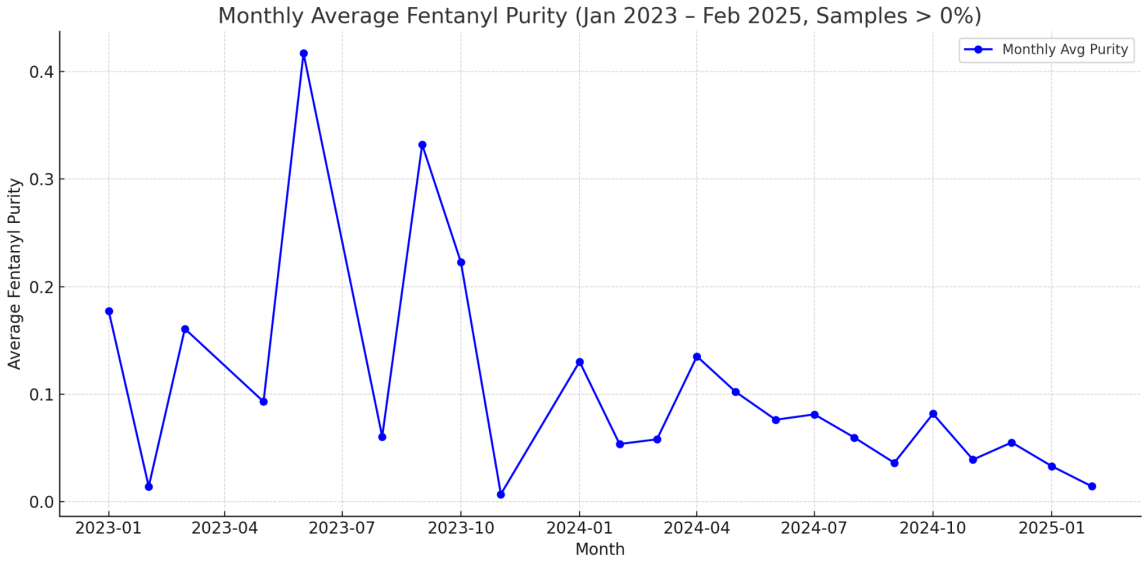
- **Targeting alerts** or naloxone distributions during months with rising volatility or purity.
- **Coordinating testing and analysis** to identify new cutting agents or contaminants.
- Monitoring correlations with overdose spikes, hospital admissions, or law enforcement activity.

Data Insights:

Fentanyl Purity

Fentanyl purity was analyzed for samples sold as 'dope', 'fentanyl', 'tranq dope', 'fent/tranq', or 'heroin' and “unknown.” We only included samples that were quantifiable (contained enough material to quantify) and contained more than 0% of the drug. We removed pills or pill fragments as well as the two highest and two lowest purity samples.

Figure 1:



Our data shows high volatility in fentanyl purity throughout 2023 with increased consistency but lower purity in 2024.The highest average monthly purity in our dataset was 47.1% in June 2023 and the lowest average monthly purity was 0.7% in November 2023, a month after the Los Chapitos faction of the the Sinaloa Cartel curtailed independent fentanyl production, and consolidated synthesis among the trusted upper echelons of the organization (The Wall Street Journal, 2023; DEA, 2024; Insight Crime, 2025)*.

Between January 1 and September 30, 2023, the average fentanyl purity in samples with more than 0% fentanyl was approximately 14.2%. From November 1, 2023, to February 28, 2025, the average purity dropped to 6.9%, representing a 51% decrease.

LOESS REGRESSION

Figure 2: Using a bootstrapped LOESS regression model that controls for sampling variability and excludes extreme or misleading samples, we observed a sustained decline in weekly median purity after the Sinaloa Cartel's ban:

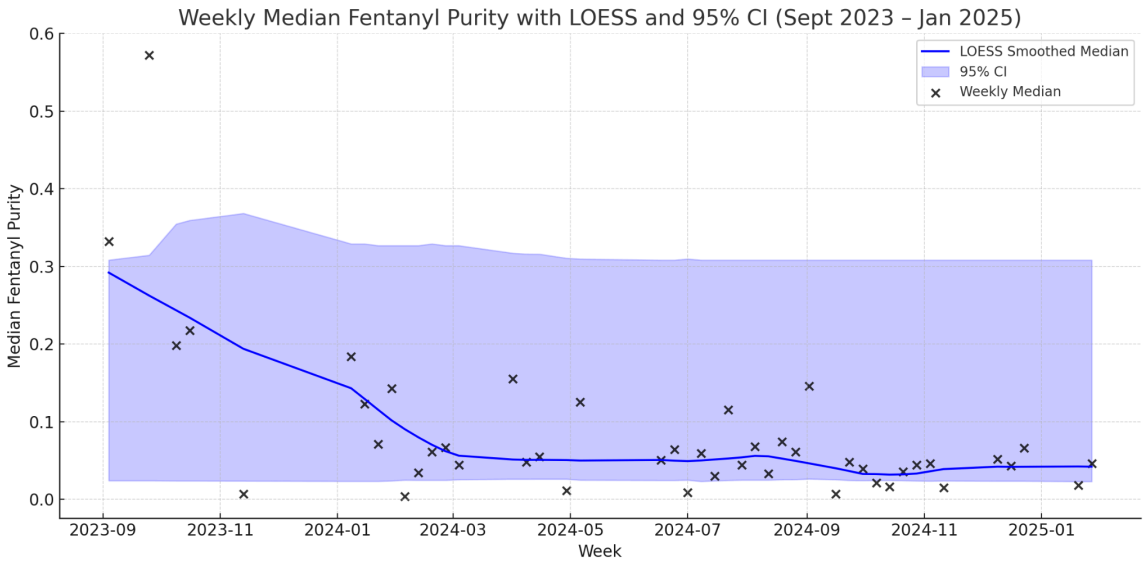
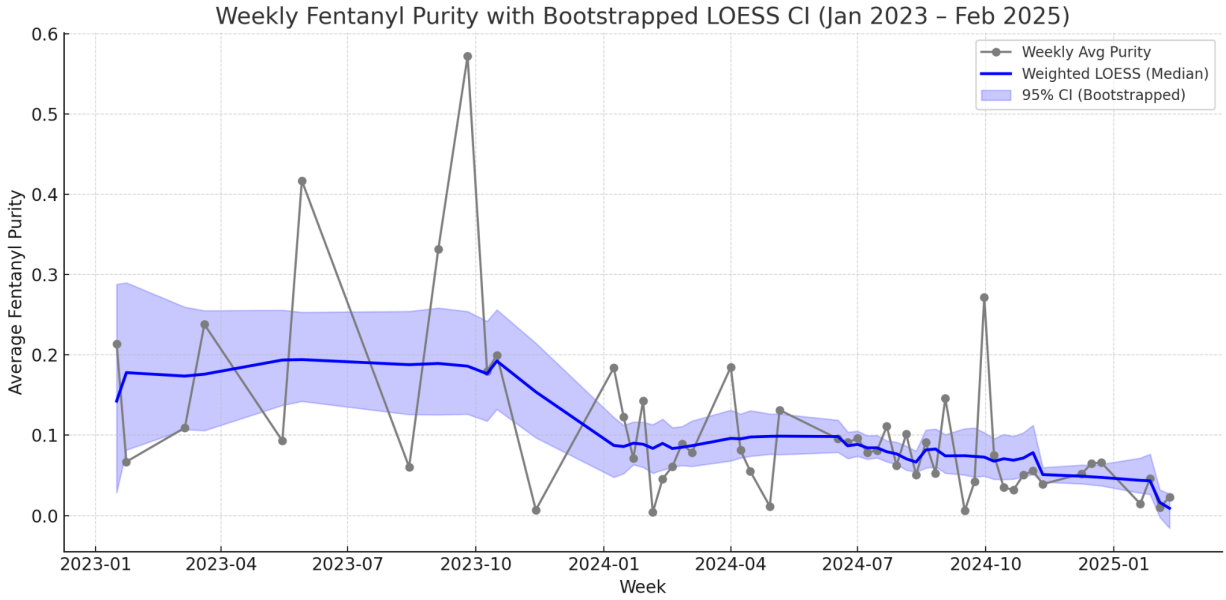


Figure 3: The below visualization gives you a more clear, time-sensitive understanding of how fentanyl purity shifts weekly, which is especially valuable for early detection of public health or market shifts.



After October 2023, the average purity of fentanyl samples dropped, consistent with what we'd expect during a supply disruption. This suggests that the drug supply was affected—dealers may have diluted what they had or reformulated their products due to

scarcity. Supply side sources interviewed by PAG reported higher prices for wholesale fentanyl and fewer suppliers to broker deals from Mexico. Some drug “sets” in Philadelphia temporarily shut down or rented their corners to other groups with better connections, one source told us.

This dynamic was later confirmed by Insight Crime in an excellent analysis of the impact of the Sinaloa Cartel’s ban on fentanyl production published in Jan. 2025 (see below). While some independent fentanyl producers have been leaving Sinaloa to accept offers from criminal groups in the northern states of Baja California and Sonora, we expect fentanyl purity to remain below peak levels as the Philadelphia regional dope supply has become increasingly adulterated with multiple new cutting agents, increasing profits for drug sellers while having minimal impact on demand..

The decline in fentanyl purity is consistent with reports from people who use illicit opioids, with whom we engage with regularly. Consumers noticed a decline in fentanyl as tranquilizers and local anesthetics have increased in the dope supply. (See PAG Adulterants report)

These findings suggest that the disruption in upstream fentanyl production may have measurably affected the potency and consistency of the street-level supply in Philadelphia, while leading to increased adulteration. Further investigation is warranted to assess public health implications, including overdose risk and substitution effects.

*The Wall Street Journal (2023). Mexican Sinaloa Cartel’s Message to Members: Stop Making Fentanyl or Die

DEA (2024). National Drug Threat Assessment

Insight Crime, How Fentanyl Producers in Mexico Are Adapting to a Challenging Market

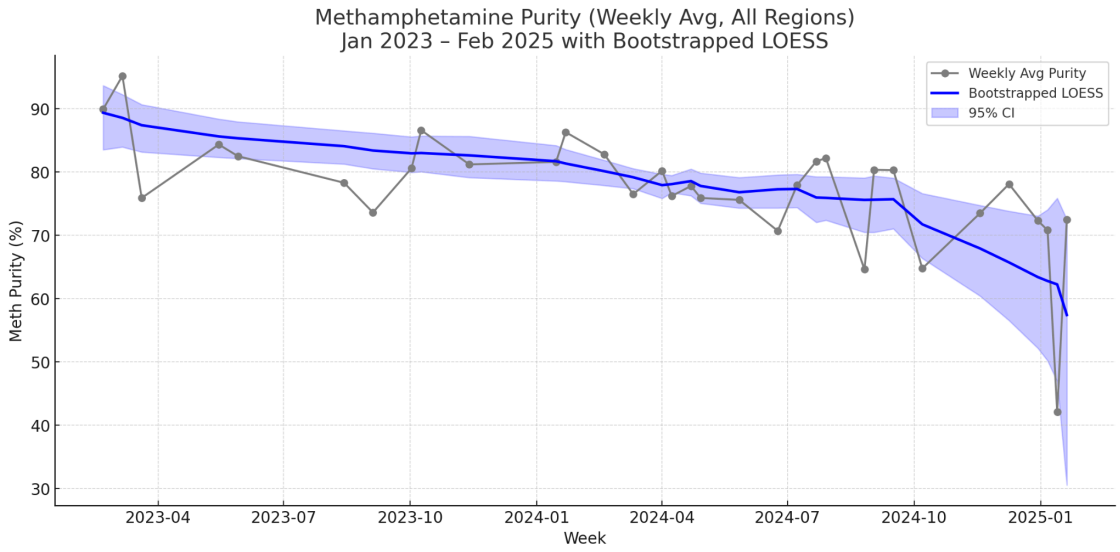
Impact on overdose fatalities

The timing of the decline in fentanyl purity correlates with a nationwide decline in overdose fatalities, and the emergence of compassionate overdose reversal strategies that focus on respiration over responsiveness and rely on lower doses of naloxone. While there are different theories as to why there was a decline in nationwide fatal overdose rates, PAG believes that lower purity fentanyl, wider adoption of harm reduction approaches and an increased number of bulking agents are primarily responsible for this dramatic shift. We and many others in the field will continue to monitor these trends as the landscape for PWUD and supportive services are ever changing.

Methamphetamine Purity

Methamphetamine purity was assessed in samples sold as 'methamphetamine' or ‘Meth.’ We removed counterfeit adderall and MDMA, which contain low dose percentages of methamphetamine with binders that could distort our data on methamphetamine purity.

Figure 4:



Between January 2023 and February 2025, methamphetamine purity in drug samples collected by PAG showed a clear and statistically significant decline. In early 2023, the average purity of methamphetamine was around 84%, but this steadily decreased to approximately 73% by early 2025. This trend was confirmed using a bootstrapped LOESS regression with 95% confidence intervals, providing a high degree of certainty that the decline was not due to random variation. Unlike fentanyl, which experienced a sharp purity drop after October 2023, the decrease in methamphetamine purity was more gradual. This suggests broader changes in supply chains, manufacturing practices, or regional cutting and distribution practices. To gain insight into the most recent drop, a sharp decline at the start of 2025, we sought information from sources in the community.

We learned that in late 2024 and 2025 complaints began surfacing in Philadelphia of meth that was predominantly “shake” (small crystals or powder as opposed to the large crystalline “shards” consumers tend to favor), and sources reported signs of adulterated batches such as discoloration, and meth that turned their pipes black or evaporated quickly when heated. This could be indicative of increased adulteration at the local/regional level and may not translate to other areas/regions. In its crystal form Methamphetamine is difficult to cut, however in smaller pieces and powder it’s easier to adulterate. Cuts identified by PAG in meth have included Dimethyl Sulphone (MSM), Inositol and salt. The drug is also relatively easy to clean using appropriate solvents and

filtration followed by recrystallization. In one case a retail level meth seller who understands this process told PAG they removed 17 grams of cut (much of it common table salt) from 32 grams of meth “shake”. Another seller reported trashing four ounces of the drug that they considered unsellable due to visible adulteration.

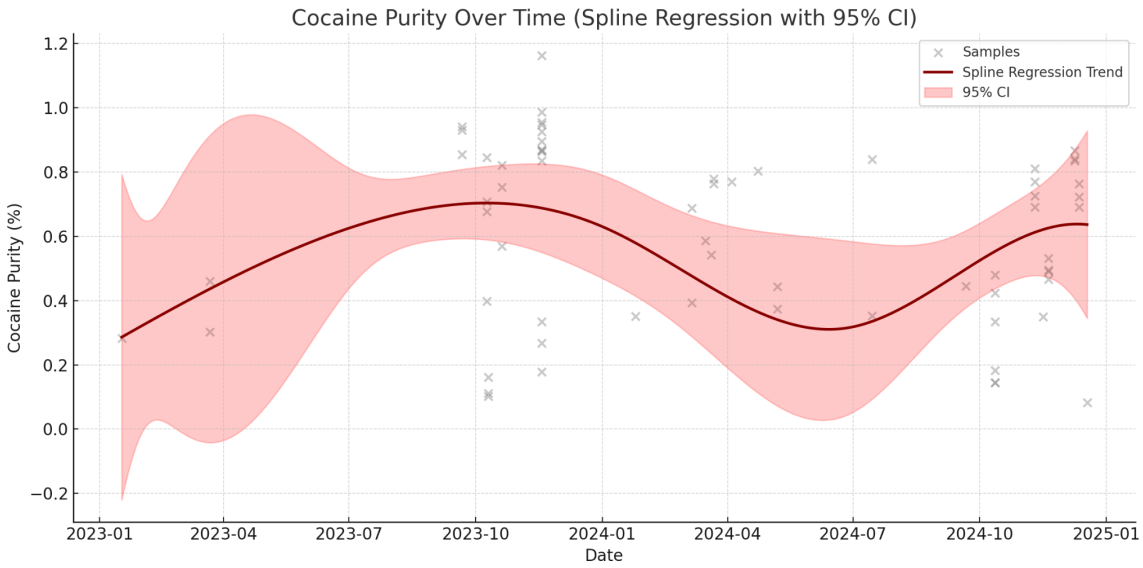
While the decline might imply reduced potency, it may also prompt people who use meth to take larger doses, increasing risks of toxicity, overamping, or unintentional mixing with other drugs. These findings highlight the importance of ongoing drug supply monitoring for anticipating public health risks and guiding harm reduction strategies.

It’s unclear if the market has corrected itself yet. However PAG will continue to monitor the situation and report back.

Cocaine Purity

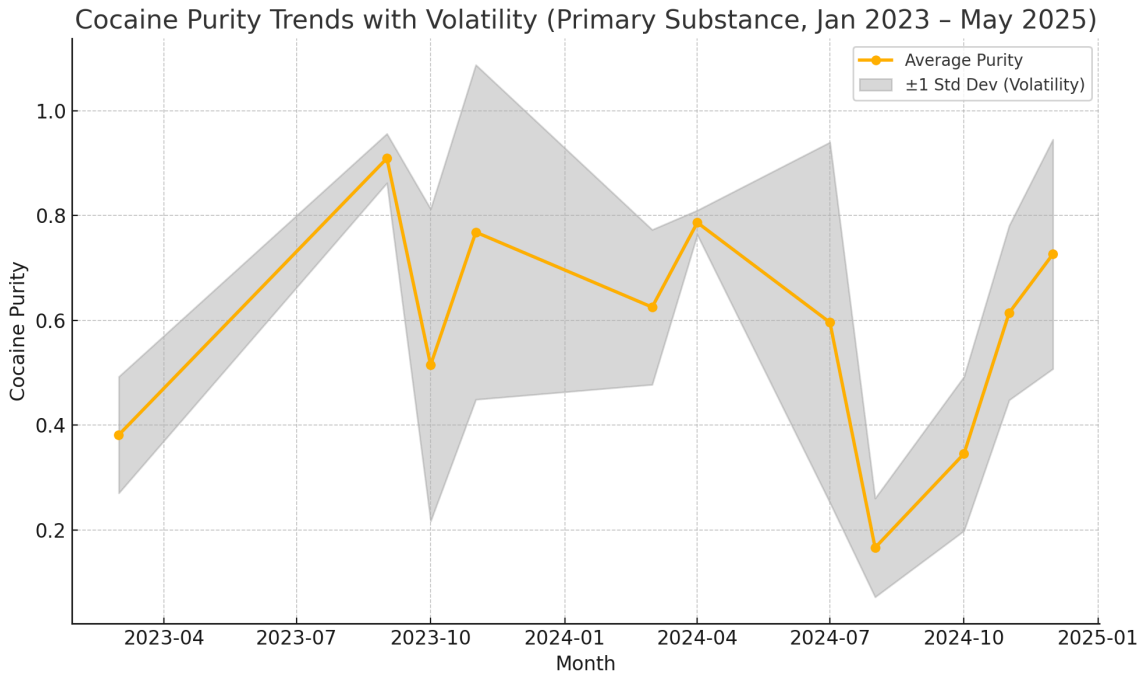
From January 2023 through February 2025, we analyzed weekly changes in cocaine purity across all lab-tested samples that were sold as cocaine, crack, coke, or “hard.”. To ensure accuracy, we excluded samples that contained no measurable amount of cocaine. Since small amounts of cocaine are often found in illicit fentanyl (dope) samples, we only analyzed samples in which cocaine was confirmed as the primary active substance. Using a flexible **spline regression**, we found that cocaine purity fluctuated over the study period, with several clear waves of increase and decrease. The spline model revealed a non-linear pattern, suggesting that purity was not stable or randomly variable—it followed discernible trends.

Figure 5:



These fluctuations may reflect **shifts in supply chains, changes in manufacturing practices, or enforcement patterns affecting** the drug market. While purity did not show a consistent upward or downward trajectory, the overall picture indicates a high degree of volatility, meaning that consumers are regularly exposed to **changing drug strength**, which may carry important public health risks.

Figure 6: Cocaine volatility



In light of demographic, socio-economic and public policy dynamics we identify drugs sold as powder cocaine and crack cocaine separately,, which allows PAG to run more granular analyses:

On average, “crack” samples had higher cocaine purity (67.9%) than those sold as powder “cocaine” (51.8%). While crack or “hard” is the same drug as powder (i.e. cocaine), powder coke is more likely to contain cuts like levamisole, lidocaine, caffeine, or dimethyl sulfone that are washed out during the process of cooking crack. The distinct differences in purity are unsurprising, but enlightening.

Xylazine Purity

Xylazine purity fluctuated widely in 2023, increasing during the first quarter of the year, then decreasing from the end of March to the beginning of September before spiking through the end of 2023. During 2024, the amount of xylazine in samples of dope (the only place it was found) declined consistently, likely reflecting the impact of xylazine's permanent scheduling in June 2024. **Our highest average monthly purity reflected in our data was 91.3% in November 2024, and our lowest average monthly purity was September 2024, at 3.85%.**This suggests that policy changes may have influenced supply chains, prompting dilution or substitution with other drugs, particularly medetomidine.

Figure 7:

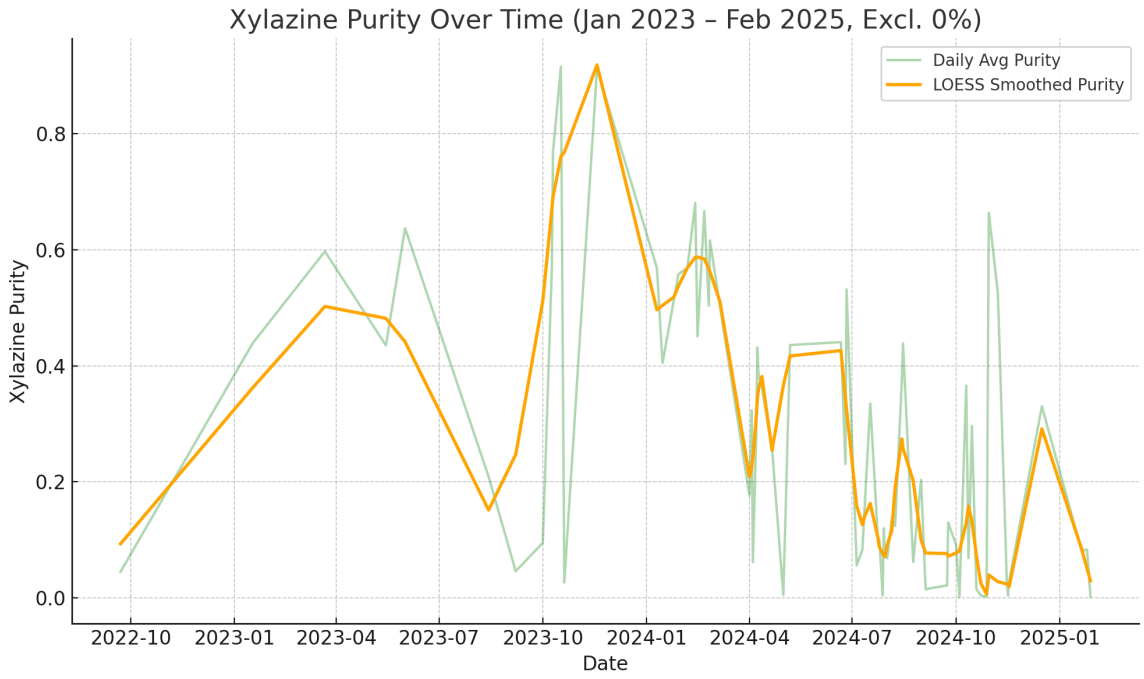
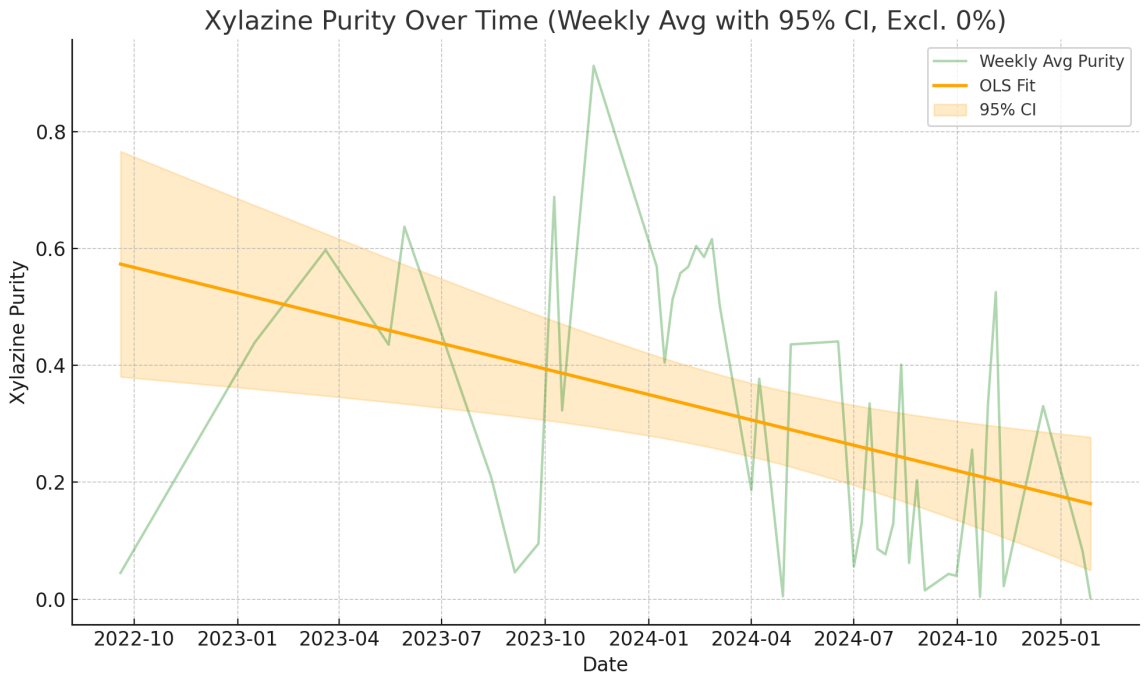


Figure 8:



Medetomidine

General Statistics

Total Samples Analyzed: 292

Ratios of medetomidine to Fentanyl in our dataset:

Minimum Ratio: 0.1 (medetomidine is 10% of fentanyl)
Maximum Ratio: 93.0 (medetomidine is 93× fentanyl)
Mean Ratio: 4.69
Median Ratio: 1.2
Standard Deviation: 12.23

Our data shows a clear decline in xylazine purity beginning in early-to-mid 2024. This decline coincides with a sharp rise in medetomidine prevalence, peaking after xylazine's scheduling in June 2024, and suggesting active substitution in the drug supply.

Figure 9:

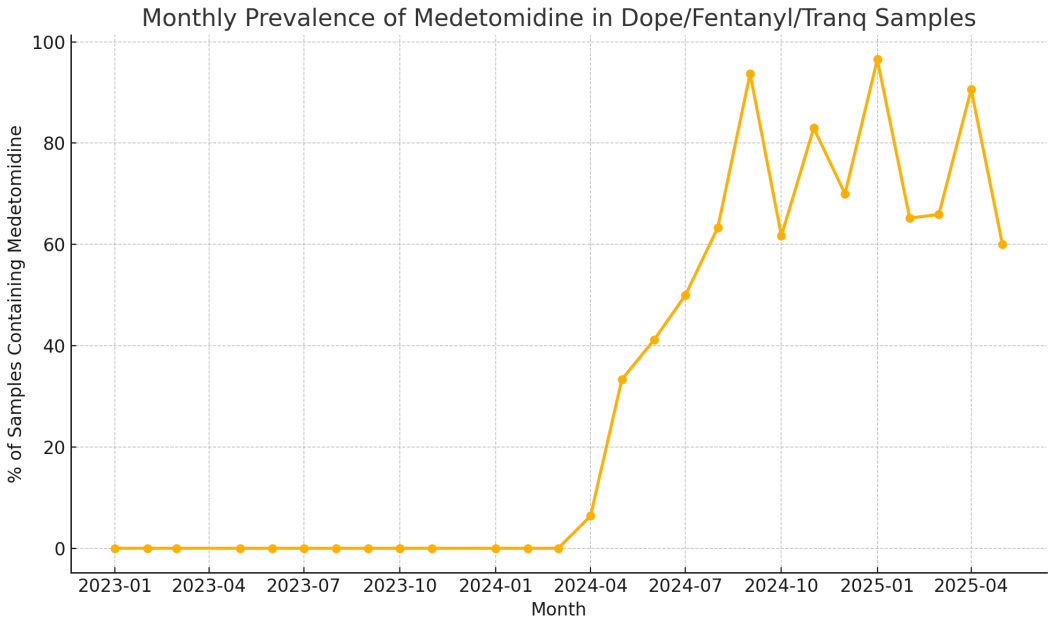
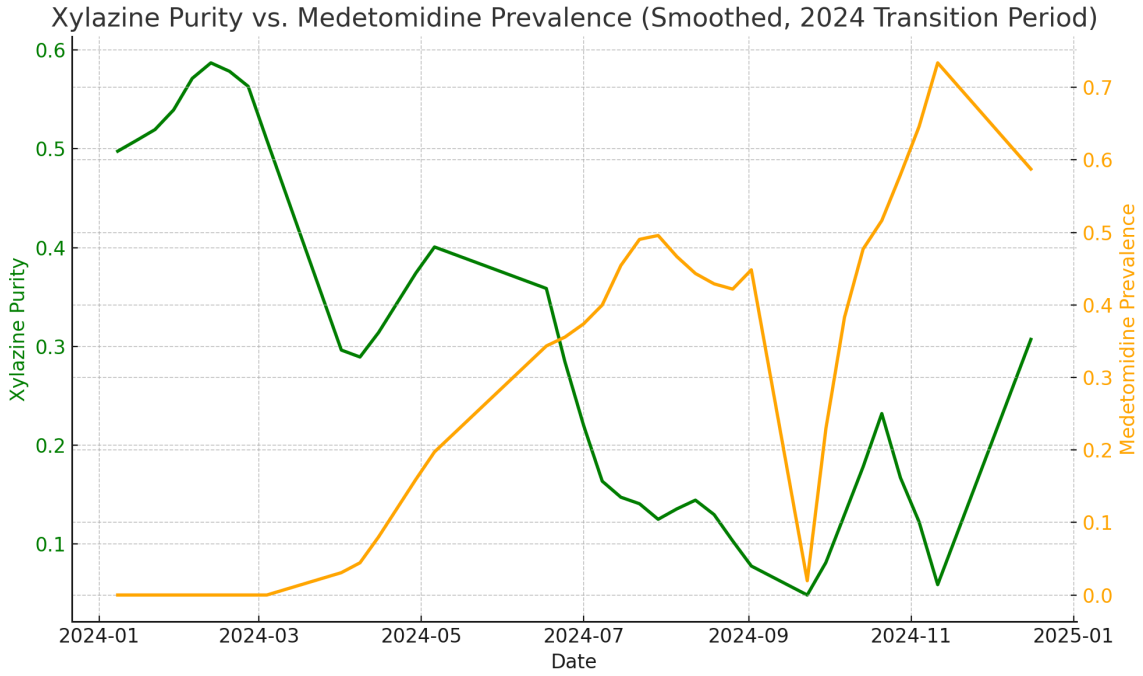


Figure 10: As xylazine purity steadily declines, medetomidine presence rises at almost the same rate:



Estimated Crossover Point:

June 21, 2024

This is the date when medetomidine prevalence first overtook xylazine purity in the data — suggesting a key moment of substitution dominance in the drug supply.

Importantly, this timing closely aligns with the June 2024 scheduling of xylazine, reinforcing the interpretation that regulatory intervention accelerated the transition.

Impact of Medetomidine Presence on Fentanyl & Xylazine Purity

Medetomidine Presence	Avg Fentanyl Purity	Avg Xylazine Purity
Absent	10.85%	28.17%
Present	4.37%	4.35%

Conclusion

While the illicit drug supply in Pennsylvania has generally declined in purity over the past two years, one could argue that high volatility and an inconsistent product have made things more dangerous and unpredictable for consumers. Meanwhile, opioid users are now facing a dual dependency as the highly potent alpha-2 agonist medetomidine has largely replaced xylazine since the latter's scheduling. Clinicians report severe withdrawal associated with medetomidine, necessitating medical intervention and frequently a stay in the ICU.Due to the importance of keeping up with changes in the active street level drug supply PAG will continue to diligently conduct this work. We are always striving to advance this project, shortening the turn around time for results, adding new substances for quantification, and expanding our geographic reach through our new national organization Groundhogs Group. As always, we thank our community partners and the CFSRE. Without the steadfast commitment of our lab partners to the field of harm reduction our organization would not exist.

To learn more please check out our website or reach out to info@pagroundhogs.org for more information.

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