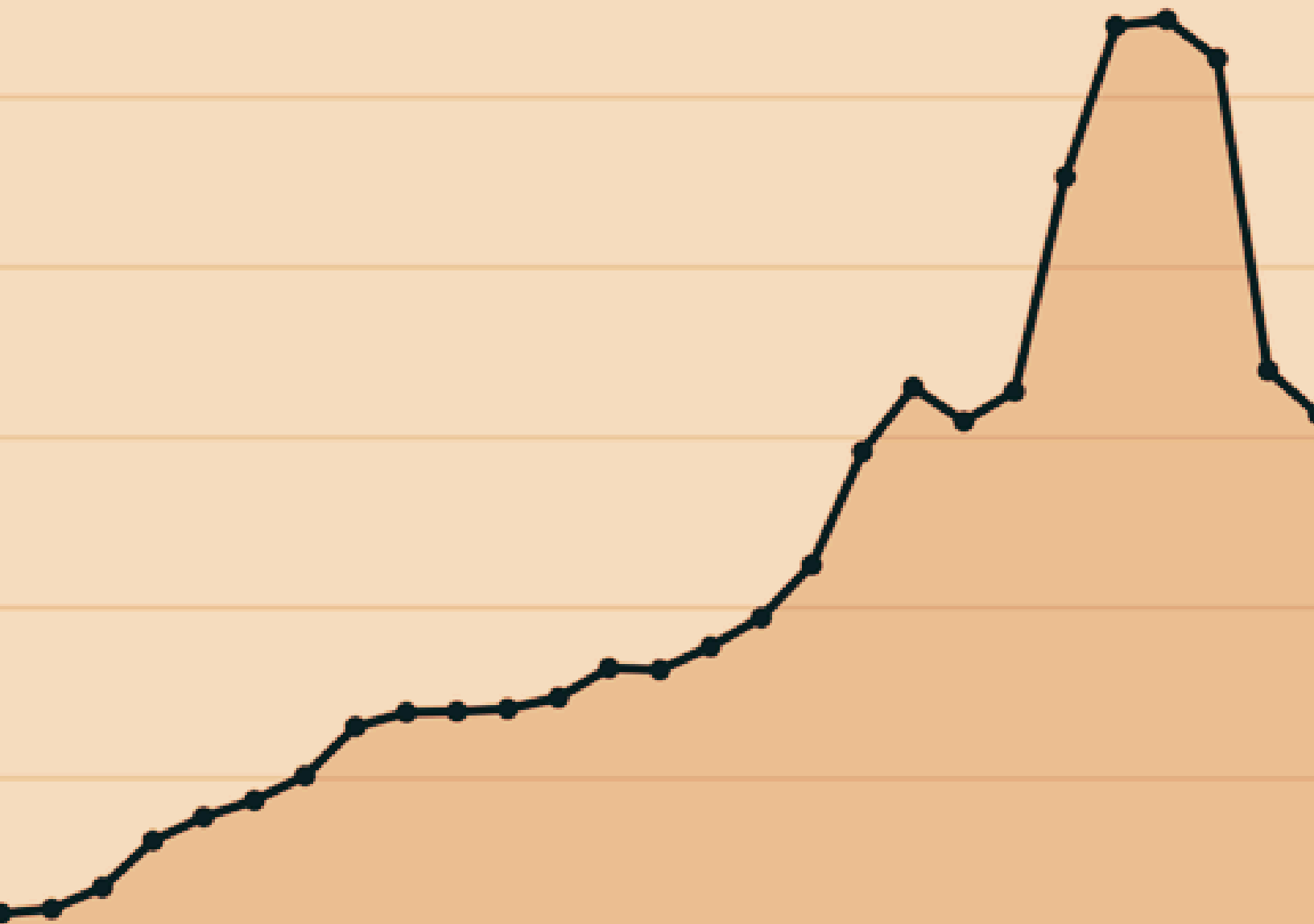




Understanding the Recent Rise and Decline of Overdose Deaths in the United States

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1. Overview

On an average day in America, there are 180 memorial services for people who died of an overdose. 180 eulogies delivered, hymns sung, wakes, and shivas sat. 180 groups of mourners lighting candles and incense with hands shaking. For loved ones saying final farewells, there is no consolation in recent overdose declines. There is only grief.

Two ways of looking at one number. Since the national peak in overdose mortality in the summer of 2023, overdose deaths have dropped 40%. Yet since that same peak, an additional *quarter million* people have died of an overdose.

So, let's be clear from the start: *We are still losing too many people we love.*

And we will continue to. For people who use drugs, the risks remain globally and historically unprecedented. Now is not the time to let up on the measures that have driven this still-nascent decline.

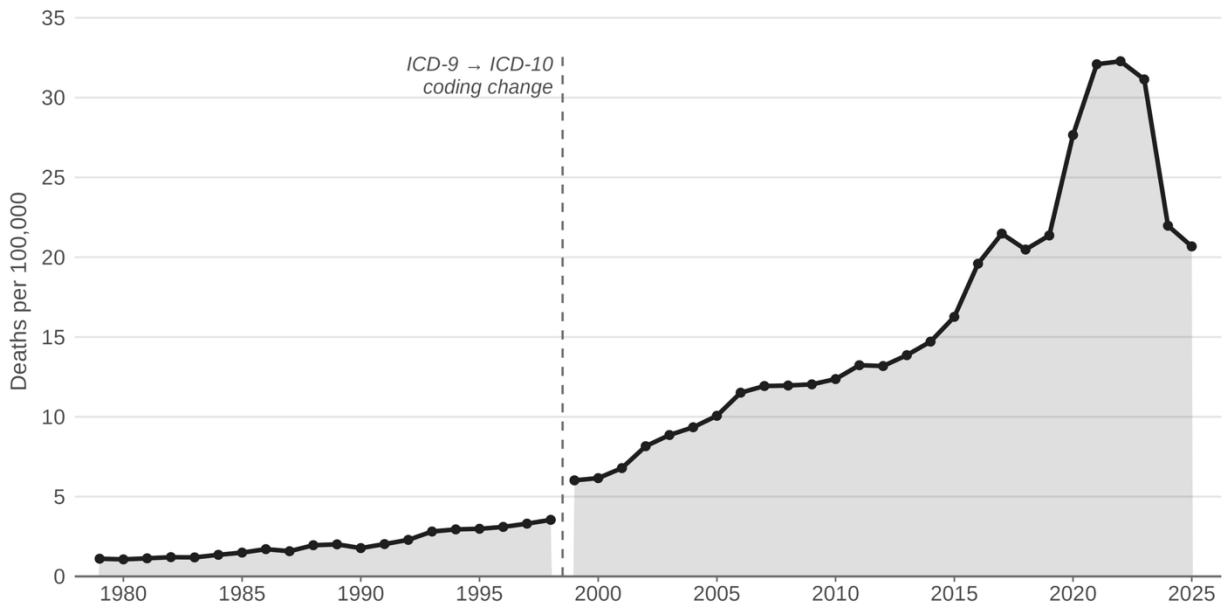
This paper explores potential causes of the overdose decline. The first section catalogues antecedents to the rapid increase in overdose deaths starting in 2020, coincident with the onset of the coronavirus pandemic. The second section interrogates three central hypotheses why overdose deaths are declining: drug supply, behavior change, and interventions. The third section explores two reasons why overdose declines seem to be mostly enduring: demographic shifts and a broader post-pandemic recovery. There follows a section on sub-populations in which overdose recovery is uneven, with corresponding opportunities to fine tune interventions. The closing addresses alternative hypotheses, and provides an overview of information sources, along with a synthesis.

1.1. *Prelude: A Historic Increase, then Decline*

The period from 2023 to 2026 represents the only enduring decline in overdose deaths since the inception of the “War on Drugs” a half-century ago. In 1979, the annual rate of drug overdose mortality was 1.1 per 100,000 U.S. residents. In 2000 on the eve of the prescription opioid overdose era, and after more accurate vital statistics were implemented, the rate was 6.2 per 100,000. In 2022-23, the rate peaked at 32.3 and 31.1 per 100,000, respectively. By April 2026 the annualized rate had fallen to 19.5 per 100,000, an ongoing four-year decline.

Figure 1: U.S. overdose death rate, 1979–2025

Overdose deaths per 100,000 population, by year



Data from CDC WONDER, processed by UNC Opioid Data Lab.

All intents, all drugs using ICD-10 codes X40–X44, X60–X64, X85, Y10–Y14.

Cause of death is coded with ICD-9 for 1979–1998 and ICD-10 from 1999 on. The line is broken at the change because the two periods are not directly comparable.

Over 1.5 million people in the U.S. have died of a drug overdose since 1979. The gray area under the curve above in Figure 1 is a paltry representation of our immense collective grief. The absolute numbers are staggering. From apex in August 2023 with $n=112,418$ annualized overdose deaths, numbers have declined to an estimated $n=66,937$ in the 12-months ending April 2026, an unprecedented decline from peak of -40.5%. We investigate this trend to make sense of the trauma we have experienced, in hope of understanding what is working, to inform policy and spending decisions, and to speed the downward trajectory to its elusive nadir at zero.

To consider what is driving the decline in overdose, we start by considering causes of the sudden increase in 2020.

1.2. Accelerations Leading to Peak Overdose Mortality

The co-timing of the sudden increase in overdose deaths with the onset of the COVID pandemic in 2020 cannot be ignored. We have [previously noted](#): “Intensifying substance use may be a normal societal response to mass traumatic events, especially when experienced by people in lower socioeconomic strata,” citing evidence from tsunamis, nuclear disasters, hurricanes, and terrorist attacks. The immense social disruptions brought on by the pandemic, starting in April 2020, fits within the established pattern. It

has been [estimated](#) that up to 49% of the increase in overdose deaths in 2020 could be due to factors related to COVID and restrictions.

Individual causes for a link are intuitive. A [review of overdose circumstances](#) in Pittsburgh revealed that deaths in 2020 rose due to people using alone, absent anyone who could administer naloxone in time. [Hesitancy for hospital transport](#) after an overdose for fear of infection, respiratory infection comorbidities from drug-induced hypoxia, [transport difficulties](#) for substance use treatment appointments, disruption of tolerance, and [finding new untrusted supplies](#) could have fundamentally modified the risk and recovery environments.

Retail supply side changes are less well-documented, but salient. [A study in Scotland](#) and [multiple analyses of online cryptomarkets](#) correspond with our team's field research in the U.S.: The loss of employment income during the pandemic drove individuals without previous experience to temporarily sell drugs, meeting surging demand for psychoactive escape. It is likely that the lack of experience in cutting fentanyl, heightened competition, and less long-term investment in market presence destabilized local markets, creating excess and unexpected variability in concentrations of fentanyl per bag/tablet during the first years of the pandemic; [in British Columbia, this variation stabilized](#) after pandemic restrictions eased. Our team has also demonstrated that illicit market [supply volatility](#) has been associated with fentanyl overdose rate increases. (Similar local market disruptions and opportunism were [documented in Denmark](#) with cannabis.) As discussed in Section 2.1.2, other international conditions around 2020 set the stage for greater North American fentanyl production and low barrier to entry.

Turning to granular empirical evidence, the four waves of coronavirus variants (Wild-type, Alpha, Delta, and Omicron strains) map closely with increases in overdose deaths. Figure 2, stratified by the four U.S. Census Regions, depicts month-over-month changes (first order differencing) in population-adjusted overdose mortality rates, calculated by [OD Pulse](#) at Northwestern University. Z-score normalization by each state's history (2018-26) allows detection of unusually strong impulses (greater than one standard deviation) in acceleration and deceleration. Simply stated, this impulse measurement allows us to visualize sudden accelerations or decelerations in overdose death rates.

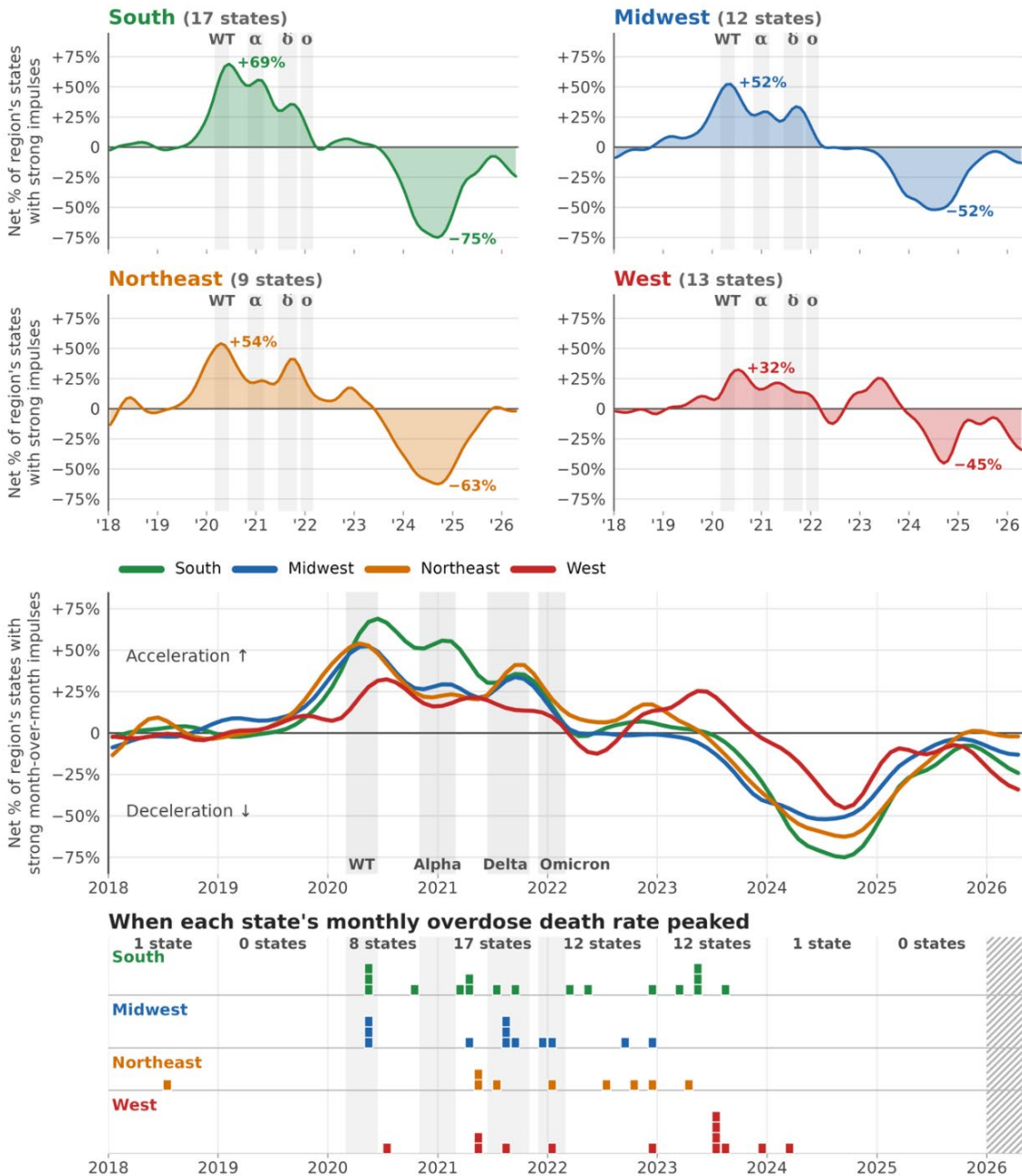
As unregulated fentanyl began to replace heroin, overdose acceleration was evident in the Northeast, Midwest, and South by 2018. Overlaying the four pandemic variant waves starting in 2020 reveals three-to-four serial impulses of overdose mortality acceleration. This pattern is most clearly seen in the South, with overdose peaks corresponding to the first three variants. Nearly 70% of Southern states experienced these waves. Notably, the fourth (Omicron) variant was not accompanied by the previous waves' civic restrictions; correspondingly, overdose death acceleration impulses became *attenuated* as social

function approached normalcy. The Midwest showed a less prominent Alpha variant-era overdose increase, which was even more attenuated in the Northeast (and some Southern states like West Virginia and Tennessee), giving the larger COVID period a distinct two-peak M-shaped increase in overdose accelerations. The Northeast also saw a further increase in overdose acceleration towards the end of 2022, which would appear to be temporally discordant with the coronavirus variant waves. Finally, the West showed the least temporal alignment between overdose deaths and pandemic variants; the West was more strongly characterized by a surge in overdose deaths as unregulated fentanyl actively replaced heroin with greater vigor, accompanied with overdose acceleration impulses in 2023.

The bottom panel of Figure 2 depicts in which month each state hit their highest overdose rate, interpretable as when declines started. Eight states, mostly in the South and Midwest, hit their peaks in 2020 during the initial phase of the COVID pandemic, with 17 peaking in 2021, and 20 more states peaking before mid-2023. The distribution over time reinforces a gradual national recovery arc, heterogeneously staggered by state, and consistent with consecutive accelerating impulses. That peak timing was not contiguous within region could imply geographically differentiated drug supplies, intervention infrastructure, or other structural factors.

Figure 2: Monthly acceleration and deceleration in OD deaths in relation to Coronavirus Strains

"As the South goes, so goes the nation." —W.E.B. Du Bois



Data from CDC via OD Pulse at Northwestern University, processed by UNC Opioid Data Lab.

Top: Proportion of each Region's states with strong acceleration ($z > 1$) or deceleration ($z < -1$) in the monthly change of the rolling 12-month overdose mortality rate per 100,000 population, January 2018 to April 2026, all USA. Middle: The same measure represented in overlapping lines for temporal comparison. Gaussian smoother applied at $\sigma = 2$ months. Grey bands mark SARS-CoV-2 mortality periods based on confirmed deaths (WT = wild type, α = Alpha, δ = Delta, o = Omicron). Bottom: Each block represents one state at its highest monthly overdose death rate since January 2018 from CDC WONDER monthly data; per state rate ties broken by the higher death count. Pennsylvania peaked in December 2016 and is shown at its highest point after 2018. Data unavailable from January 2026 onwards, hatched area at right.

1.3. *Decelerations in Overdose Mortality*

For all regions, the greatest decelerations occurred in 2024 (Figure 2), and applied to many regions simultaneously. Notable decelerations were evident in the Northeast and Midwest before mid-2023, the same time that the West was showing some of its strongest accelerations. Our team, and others, have also modeled [this regional heterogeneity in-depth](#), and found [caution against](#) an exogenous single-cause explanation for 2023 to be the national overdose death inflection point.

Calendar year 2025 also showed a slowing down of deceleration, with a few states in the Northeast briefly moving into positive territory with increasing overdose deaths month-over-month. Into 2026, the South, Midwest, and West show encouraging signs of overdose deceleration resumption.

Synthesizing these empirical observations, the recent period of exponential increase in overdose deaths (2020 to 2023) appears to be the culmination of successive impulse waves of acceleration, particularly in the South, Midwest and Northeast. Conceptually, this can be likened to consecutive tsunami waves generated by an underwater earthquake; each wave impulse building on the momentum of the previous, with later waves being the most destructive cumulatively. It is open to debate if the 2023 and 2025 attenuations in deceleration should be considered aftershocks, or extraneous to pandemic-era impulses. The [east-to-west spread of fentanyl](#), appearing in overdose acceleration in the West Region starting in 2020 and intensifying in 2023, suggests the need to more carefully consider the influence of drug supply.

Broadly summarizing [earlier drug cycles](#), rapid drops in overdose more likely represent sudden shifts in drug supply. These dips are usually [transient](#). Conversely, gradual sustained declines imply the impact of structural factors including interventions, behavior change, and long-run demographic shifts. This distinction has important implications for public health policy. If the decline is substantially attributable to drug supply changes, greater attention should be paid to preventing cycles of established drugs being substituted with newer more potent replacements. If the increase and decline appear linked to broader societal, demographic, and behavioral patterns, overdose prevention will need to adopt more integrated multi-sectorial solutions.

2. Hypotheses for Overdose Decline

Having established baseline time dynamics in overdose rates, the next step is exploring etiology. Already we can intuit that: 1) changes in drug supply, 2) behavioral adaptations among people who use drugs, and 3) public health and clinical interventions enacted in response to skyrocketing overdose rates can provide off-ramps that give people options to avoid harmful use. It is also clear pandemic-era impulses drove overdose deaths to their

zenith, and in most regions of the country the end of the pandemic was accompanied by a gradual drug mortality attenuation. The West, where fentanyl arrived most recently, correspondingly displays more recent recovery. Overdose trajectories vary by state and region, and the interplay between all these factors could be explanatory.

2.1. Major Changes in American Drugs

2.1.1. Beyond the Prescription Opioid Era

Opioid analgesic prescribing in the United States [peaked around 2012](#) and has been steadily declining. That decline continued through both the pandemic-era surge in overdose deaths and the subsequent reversal: [national dispensing rates](#) fell from 46.8 prescriptions per 100 persons in 2019 to 35.4 in 2024. By 2023, nearly seven in ten overdose deaths [involved fentanyl](#), overwhelmingly from the unregulated supply. Change in opioid prescribing alone therefore provides an incomplete explanation for the recent rise and decline in overdose deaths.

The relationship between receiving an opioid prescription and subsequently dying of an overdose also requires attention to timing. In a [study of Kentucky overdose deaths](#), only 11.6% of decedents had an opioid analgesic prescription dispensed in the month preceding death. Among those with histories of hydrocodone or oxycodone dispensing, the median intervals from the last prescription to death were 3.6 and 3.9 years, respectively. Patients abruptly discontinued from their medications enter a pool of at-risk individuals when medical systems force them to turn to illicit supply to meet needs. That there are years between last prescription and overdose shows there is time to provide support and also hints at complex etiology.

[One sophisticated model](#) predicted that the decades-long trend in overdoses would begin to decline in 2023. That model anticipated the decline in overdose deaths to be a function of fewer people being introduced to (illicit) opioid use via pharmaceutical opioids, as well as mounting public health and clinical capacity.

These findings suggest complex, protracted pathways linking earlier prescription exposure to later overdose. Reduced prescribing may [influence the population at risk over longer periods](#), but explaining the recent mortality trajectory requires examining what people were actually consuming. The focus therefore turns to the changing composition, availability, and use of illicitly manufactured opioids.

2.1.2. International Policy and Interdiction

Before isolating specific changes in the drug supply during the rise and fall of overdose deaths, it is important to review the international context briefly. The focus is on the interplay between organizations in three countries: China, México, and the United States.

The central government of the People's Republic of China (PRC) [outlawed the export](#) of fentanyl products and raw material in late 2017, with the UN International Narcotics Control Board [following](#) in early 2018. Paradoxically, the steepest increase in drug overdose deaths ever recorded in the U.S., driven by illicitly manufactured fentanyl, immediately followed. At the time of these government and multilateral actions, the annualized U.S. overdose death rate was around 21 per 100,000 in early 2018. By February 2023, the annualized rate had skyrocketed +66%, to 33 per 100,000, in the midst of the COVID-19 pandemic. During this time, despite the 2017-8 bans, exports of raw material from China continued to a handful of México-based multi-national organizations, which then employed [American citizens](#) to import bulk product into the U.S.

In China, the central PRC government's directives to limit manufacturing has often been superseded by corrupt provincial government officials, with chemical manufacturers taking advantage of the vast volume of general trade and limited inspections to route clandestine exports. It was not until 2023 that a written directive circulated by the central PRC government and ramped up enforcement could have [plausibly led to disruptions in fentanyl supply](#), putting these actions in temporal proximity to overdose declines in some US regions.

In México, while political focus has been on two large multi-national cartels, [local intelligence](#) reveals that individual manufacturers within the territories nominally controlled by these cartels operated independently. Paralleling the aforementioned lower barrier to entry into illicit economies during the pandemic domestically, small-scale producers in México were served by a complex network of intermediary brokers, wholesalers, and downstream customs officials, creating a reinforcing shadow economy. In May 2023, the Chapitos faction of the Sinaloa Cartel instituted a ban on [cottage industry fentanyl production](#) and started requiring clandestine licensing permissions, which were often enforced with brutality. By the summer of 2024, amidst an [internecine battle](#), the [wholesale price](#) for a kilogram of fentanyl locally doubled to USD \$6,000. Beyond the two headline drug trafficking organizations, a handful of [medium-sized cartels](#) also participate in the competitive marketplace. In October 2024, the arrest of a major broker, a Chinese national, in México City, further [roiled clandestine distribution routes](#), particularly to Los Angeles and Atlanta.

The U.S. is a large, diverse country, characterized by both illicit drug importation and domestic production, hundreds of ports of entry, regionalized drug markets, and a mix of prescription and unregulated opioids, sedatives, cannabis, psychedelics, and stimulants serving somewhat distinct, but nevertheless massive, consumer populations.

Collectively, conditions in these three countries foster a diverse, adaptable, and diffuse drug production and distribution system. The first takeaway is that central government

interdiction may be a weaker force than presumed in influencing long-run overdose rates. The second takeaway is that the groundwork had been laid for an inflection point in the illicit drug supply during the late stages of the COVID-19 pandemic.

2.1.3. Changes in Fentanyl Concentration

One highly publicized theory forwarded by the [Drug Enforcement Administration \(DEA\)](#) and [Vangelov et al.](#) attributes the decline in overdose deaths to lower fentanyl “purity” beginning in 2023, attributing the drop to either interdiction in México or China. However, upon [independent replication](#), we found that stimulated reporting of wholesale samples by DEA may have led to an undetected data artifact, resulting in spurious associations. Further, if a “supply shock” led to lower fentanyl purity in isolated locations, its impact appears to be geographically inconsistent: In the South, where 44% of samples came from, there was no correlation between overdose mortality and DEA fentanyl purity data, in neither the rise nor fall of overdose rates.

Still, based on Figure 2, a constriction of fentanyl supply may well have happened, but more likely in 2024. This is corroborated by multiple sources. Urine testing among patients entering methadone and clinical treatment, revealed the [concentration of fentanyl](#) had [declined](#), combined with an [increase](#) in [xylazine](#). In [commercial urine drug screen data](#) from clinics and job seekers, fentanyl metabolite quantities saw a lull from June through December 2024, particularly in the Western half of the country, inversely mirroring a compensatory increase in heroin; fentanyl concentrations appear to have rebounded somewhat in early 2025. A similar pattern emerges independently from [wastewater surveillance](#), with February through October 2024 showing a swooping drop in sewer fentanyl concentration; however the geographic sampling frame is not disclosed by the commercial testing company. [Drug checking data from Philadelphia](#) and the [mid-Atlantic](#) point to mass adulteration, with 67% to 82% of fentanyl or heroin samples containing medetomidine by the first half of 2025.

[In Los Angeles](#), stamp bags of “dope” contained <1% to >20% fentanyl, suggesting that retail supply is highly variable, [similar](#) to [findings](#) in British Columbia. The same [community drug checking service in Los Angeles](#) reported average fentanyl purity of 12.5% from September 2023 to January 2026; [a different lab corroborated](#) higher fentanyl concentrations in the West, from 11.4% to 15.8% in 2025. Other labs in the [United States](#) and [Canada](#) reported fentanyl retail concentration appearing to remain steady or increasing from 2020 to 2023Q3. [Quantitative analysis](#) from Spring 2025 to April 2026 show no change in the quantity of fentanyl per bag, around 5% in the Mid-Atlantic, despite the increase in overdose deaths in this region. These wide ranges and discordance with overdose mortality underscore that fentanyl concentration varies widely by drug market and sampling methodology, and that connections to OD mortality are [difficult to prove](#)

regardless of plausibility. As discussed in the next section, the missing link may be adulteration.

To recap, when aggregated to the national level, overdose declines *appeared* to peak in Summer 2023, but the greatest rate of decline happened in 2024, coincident with possibly lower fentanyl availability. But, quantitative analysis revealed variation and adulteration. Other data are needed to understand what else was happening in the drug supply in 2024 during the period of strongest deceleration.

2.1.4. Drug Supply Adulteration

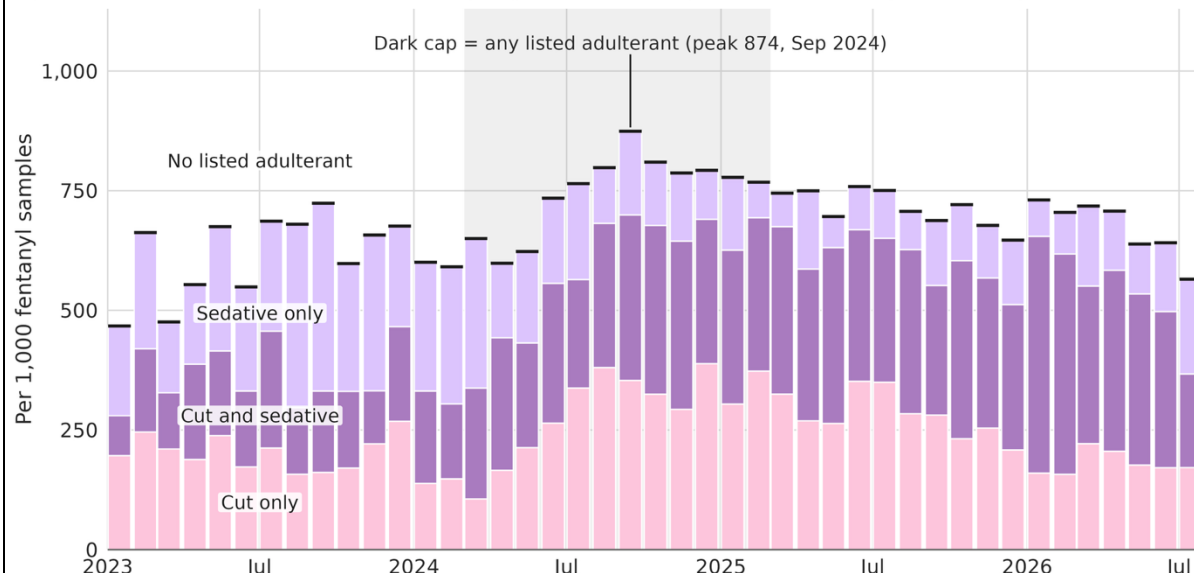
The realignment and inter-cartel competition in 2024 is temporally aligned with observable retail drug supply changes, layered on top of already abating overdose rates. Based on mass spectrometry of donated drug samples (Figure 3), we the [UNC Street Drug Analysis Lab](#) (and [others](#)) report that starting in early 2024 there was a massive influx of adulterants into the unregulated fentanyl supply across the country, in rough order of spread: [local anesthetics](#) (procaine, lidocaine, tetracaine), [caffeine](#), [xylazine](#), [BTMPS](#), diphenhydramine, and a little later, [\(dex\)medetomidine](#). Among lab samples we have analyzed at UNC, more than 90% of expected-fentanyl samples historically contained fentanyl in substantial quantity; however starting February 2024, more than 20% of expected-fentanyl samples only contained trace amounts of fentanyl. Local anesthetics were particularly pronounced in the Northeast initially, and then the South and Midwest. By contrast, BTMPS traveled west-to-east; and diphenhydramine, historically established in the Midwest, started leaking into the South with more frequency.

In our lab analysis, [xylazine among fentanyl samples](#) in the West have been considerably lower (around 10%) than in other regions (peaking around 60% in mid-2024). Since early 2026, medetomidine has overtaken xylazine as the primary alpha-2 adrenergic agonist adulterant in the American drug supply. Adulteration of fentanyl with xylazine has been shown to result in [compensatory protective behavior](#) to use less or less frequently, change routes of administration, and seek treatment. Xylazine-fentanyl combinations have been noted to cause [less severe overdose](#) in animal models and [tertiary medical settings](#). Yet, human xylazine use is known to result in [serious skin wounds](#), and [medetomidine withdrawal](#) can cause severe cardiac emergencies: Adulteration should not be treated as a public health strategy, and introduces novel and difficult-to-handle harms.

Adulteration of fentanyl with these agents may have had an impact on overdose mortality, but it was neither a humane nor intentional public health strategy. Illicit drug markets are not all-powerful, and they routinely make adaptations that are consumer turn-offs. This consumer dissatisfaction then can induce motivations for behavior change.

Figure 3: Major adulterants of fentanyl samples, state-weighted

By adulterant class, each state counted equally each month, by month collected, Jan 2023 to Jul 2026



Donated samples (n=9,255) analyzed using GCMS.

Drug checking data from UNC Street Drug Analysis Lab, processed by UNC Opioid Data Lab.

Weighted so each state counts equally each month (inverse sampling weights): each sample's weight is 1 / the number of fentanyl samples from its state that month. States with fewer than 5 samples that month are pooled with the other small states in their Census region, and a regional pool still under 5 is pooled nationally; each pool counts as one state. 2 samples with no state are excluded. Denominator: Samples with fentanyl in primary abundance by month of sample collection. An adulterant counts if detected at any level (primary or trace). Each sample is counted once, so every bar sums to 1,000; the unfilled space above each bar is samples with no listed adulterant. Cut = numbing agent, BTMPS, acetaminophen or caffeine. Sedative = xylazine, medetomidine, diphenhydramine or bromazepam. Any cut = bottom two layers; any sedative = middle two layers. Numbing agents = lidocaine, procaine or tetracaine. BTMPS = bis(2,2,6,6-tetramethyl-4-piperidyl) sebacate. Mail-in samples from community programs; not a representative sample of the U.S. drug supply. Grey shading marks the peak deceleration of overdose deaths, Mar 2024-Feb 2025.

2.2 Behavior Changes

People who use drugs actively responded to changing risk environments. Their decisions connect changes in the drug supply with the public health and clinical interventions described below. One plausible pathway: unwanted changes in supply create motivation to change use; an accessible way to act makes that change possible; and continued support can help sustain reductions in exposure or risk.

Broadly conceptualized, interventions serve as off-ramps, guiding departures from harmful use. They give people options, including using less, using less often, changing consumption practices, entering treatment, or managing substance use outside formal care. Abstinence is one possible outcome, as is switching to less immediately toxic substances. The broader question is how people find ways to keep themselves alive, when all around them their peers continue to succumb to overdose.

2.2.1 Drug Supply Dissatisfaction

Even as adulteration of fentanyl synergistically contributed to already decelerating overdose mortality, harms from these additives were [resoundingly panned by consumers in many studies](#). Earlier research of [illicit drug dissatisfaction suggested](#) low-quality drugs may not lead people to find new suppliers when everything appears adulterated. Paralleling consumer dissatisfaction, in North Carolina, a drug dealer stopped selling *because* the supply was so heavily adulterated:

*When [she] learned [via a drug checking service] what was in the drugs she was consuming and selling, “I was just amazed. I was, like, ‘Holy s**t. It’s almost pure xylazine; no dope in it.” She then stopped selling, and she was soon ready to give it up herself. She’s been drug-free for more than a year and a half.* ([source](#))

The drugs that replaced or adulterated fentanyl did not provide the same desired effects as the original, which itself was a step removed from perennially favored heroin. Interestingly, the word we keep hearing in our drug checking service at UNC is people asking for “options.” [Qualitative research](#) documents the behavioral consequences of this dissatisfaction. In interviews recruited through harm reduction programs in Pennsylvania and Michigan, participants overwhelmingly preferred opioids without xylazine. Almost all reported adapting their use, including reducing amount or frequency, changing routes of administration, abstaining, or seeking treatment.

These decisions reflected fear of wounds and limb loss, unwanted heavy sedation, loss of functionality, vulnerability to assault when incapacitated, and concerns about overdose reversibility. The changing supply increasingly failed to provide the experiences people sought, while introducing harms they wanted to avoid. [Participants’ accounts](#) and [clinical support](#) demonstrate people were responding to the adverse supply conditions by attempting to change their use elsewhere too.

These strands of evidence establish a behavioral pathway, rather than a direct mortality effect. They also identify an opportunity: when people become motivated to reduce harmful or unpleasurable use, public health and clinical services can help them take action. In between, people wanting change take their own steps towards recovery.

2.2.2 Self-Directed Off-Ramps

Protective actions by people who use drugs are ubiquitous but empirically unmeasured; the scientific literature too heavily leans into the narrative that people who use drugs [lack agency](#) and are [objects](#) in need of “[saving](#).” In reality, people who use drugs have [always](#) looked out for each other, more accurately than: “[saving our own lives](#).”

One particularly consequential behavioral adaptation has been the shift from injecting fentanyl to smoking. A [longitudinal study in San Francisco](#) documented substantial

reductions in injection frequency as fentanyl smoking increased between 2018 and 2020. [Qualitative research](#) describes people deliberately making this transition to avoid overdose, preserve damaged veins, and maintain greater control over their daily functioning. These perceived benefits have [empirical support](#): In California, those reporting fentanyl injection had 40% higher recent nonfatal overdose rates than those who exclusively smoked, alongside substantially more skin and soft-tissue infections. Smoking and snorting still carry risk, and these observational findings do not establish how much route changes contributed directly to national mortality declines. In fact, smoking is believed to have been a [west-to-east phenomenon](#) operating years before the inverse [westward expansion](#) of fentanyl. Perhaps the [quicker recovery from peak overdose in the West](#) has basis in smoking practices, the continued presence of black tar heroin, and pill dominance. Switching to less risky routes than injection is one important off-ramp from a more harmful form of use. Harm reduction organizations can support these self-directed adaptations by providing smoking supplies, overdose education, and continued access to naloxone.

[Drug checking](#) offers one more accessible off-ramp: it tells people what is actually in their own drugs. Hundreds of [drug checking services](#) now provide machine-based point-of-care results paired with options for modifying risk or cessation. But these programs have proliferated only in the last few years and have limited geographic scope, so their contribution to national overdose declines is secondary at best. However, during the rapid rise and fall of overdose deaths, test strips were the low-tech, low-cost entry point, and widely distributed. Early in the fentanyl era, the [FORECAST study](#) in Baltimore, Boston, and Providence found that 70% of people who use drugs said knowing their drugs contained fentanyl would change their behavior. People with a positive fentanyl test strip result had four to five times the odds of changing how they used, including using less, in [North Carolina](#) and in a [three-state study](#). [Among women in Baltimore](#), daily opioid use fell from 77% to 56%, and using alone from 96% to 68%, within a month of getting strips. These early studies were from an era when “options” meant being able to avoid fentanyl by seeking heroin. As fentanyl approached near-ubiquity, that option has (mostly) disappeared. And so it is natural that people seek other options.

Off-ramps also include self-directed efforts among people unwilling or unable to obtain formal care. In a [survey of kratom users](#), 41% reported using the plant to reduce or stop prescription or illicit opioid use, with reported benefits for withdrawal and craving. Much less common are ibogaine, [tianepetine](#), and the [orphine SR-17018](#) which some people use to reduce or discontinue other opioids, and unlikely to have contributed measurably to the observed overdose declines. When the dominant illicit drug market (as well as substance use treatment providers) offer unsatisfactory options, the emergence of new substances is predictable. What is unique about the last half decade is that considerable novel

psychoactive exploration, both informal and [government sanctioned](#), is directed at finding off-ramps to drug habits that people found increasingly unsustainable.

Recognizing these efforts does not establish that every substitution reduces harm. Nor are these individual molecules being asked to bear the sole weight of explaining the national overdose decline. But it does establish that treatment enrollment numbers are an incomplete measure of people's attempts to change their lives and that pharmacological off-ramps are being actively sought. As long as these substances remain available, public health and clinical engagement can encourage positive changes through continued contact, practical support, and opportunities to reassess what is helping. Common sense regulation could, in theory, ensure product quality while maintaining low-barrier options.

2.2.3. Fentanyl acculturation

Linking drug supply and behavior is fentanyl acculturation: the process through which people and their networks adapt as fentanyl becomes unavoidable in local drug markets. The time elapsed since fentanyl's arrival may afford opportunities to learn about its effects, share protective practices, and develop more effective responses.

A [preprint analysis by Sibley, et al.](#) reveals a population-level pattern consistent with this possibility. Modeling the east-to-west displacement of heroin by fentanyl from 2015 to 2025, our team found that additional fentanyl market penetration was most strongly associated with increased mortality during *early active* heroin displacement. That association weakened as markets approached fentanyl saturation. Nationally, the modeled fentanyl-associated mortality component stabilized after 2022, just as observed mortality was peaking.

This pattern does not establish behavioral adaptation as the cause, nor imply that fentanyl itself became safe. It suggests that the mortality consequences of fentanyl's spread varied across phases of market transition and geography, encompassing drug user behavior and influenced by public health and clinical improvements. Within drug-using networks, adaptation can include changes in consumption, naloxone carriage, and [collective knowledge about overdose response](#). Community organizations may support these adaptations while learning from the people developing them.

2.3. Public Health and Clinical Interventions

Motivation alone does not make change possible. Someone may want to use less fentanyl while still needing to manage withdrawal, pain, or the conditions that made continued use imperative. An off-ramp must be accessible at the moment someone is willing and able to take it.

This is where public health and clinical interventions extend the behavioral explanation. A trusted outreach worker can help translate readiness for change into a connection to care.

A low-barrier clinic can provide medication on demand. Supportive housing can create conditions in which a person has more room to manage their substance use. Programs that bring harm reduction and recovery services together can maintain contact across individually evolving needs. Each can help close the distance between wanting something different and having an accessible way to act. They provide the sought-after “options.”

A diverse drug market in a diverse country would naturally be expected to beget diverse solutions. Over the last decade, the unprecedented rise in overdose mortality spurred an extensive public health response, supported at the federal level with funding and policy changes, as well as locally through opioid settlement funds. While these efforts were not uniformly implemented, the national scope of multi-sector engagement in overdose prevention has been unprecedented.

Some of the strongest evidence that overdose deaths can be prevented comes from public health and clinical interventions. This applies specifically to interventions that have been shown repeatedly to be protective and are [evidence-based](#). Establishing how much they can explain the recent national decline is a different question. It requires understanding who received these interventions, when they received them, and what those interventions made possible. Harm reduction and medical services can prevent an overdose from becoming fatal, help people act on decisions to change their substance use, and support those changes over time.

The unprecedented magnitude of interventions enacted across the country cannot be overstated. [Much of this work happens quietly](#), by dedicated professionals and volunteers. They continue to show up for their jobs because they find their work meaningful, even in the face of political opposition. They can see the changes in the lives of people they touch. That much of the work led by women and people with lived experience goes underrecognized in scientific studies is sadly unsurprising.

Some examples: Encampment outreach connecting unsheltered people to overdose prevention, medications for opioid use disorder, and housing through [Avivo in Minnesota](#); integrating syringe services, street medicine, and harm reduction vending machines with clinical care through [Health Brigade in Virginia](#); peer-led overdose response training in jails and naloxone in release packages through [FIT Clinic in Louisiana](#); a youth OUD prevention program on [South Dakota's Pine Ridge Reservation](#); training incarcerated people to provide overdose prevention education to their peers through [Step-Up in Indiana](#); supportive housing that keeps mothers and children together through [Amethyst Place in Missouri](#); whole-family housing and peer-led harm reduction through the [Reno Initiative for Shelter and Equality in Nevada](#); free, low-barrier access to long-acting injectable buprenorphine and peer support through [Olympia Bupe Clinic in Washington](#); community-based harm reduction through [Charm City Care Connection in Baltimore](#) and community EMS providing

addiction services in [Maryland](#); [pharmacy-based methadone](#) dispensing in Appalachian North Carolina; expanded syringe services through [Challenges in South Carolina](#); and bringing harm reduction services, recovery coaching, and treatment under one roof at the Access Center operated by [ME-RAP in Maine](#). Each of these programs can definitively point to individual success stories. They can unequivocally say they are changing lives.

These unheralded heroes can observe individual benefits directly. Yet, those providing direct service have a necessary level of professional humility: Most providers, whether in the hospital emergency department or at a syringe service program, are loath to take credit for declining overdose rates. They know substance use disorders have complex multi-layered origins, and no single intervention is likely to address them all.

From an evidentiary perspective, there is a [core of evidence-based interventions](#) most likely to contribute directly to overdose declines. Alongside immediate protection, these programs can provide off-ramps from harmful use: opportunities to reduce exposure, manage substance use, enter treatment, or sustain changes that people have chosen for themselves, the behavioral pathways explored in Section 2.2. For many, the entry points are low-barrier public health programs comprising the infrastructure painstakingly assembled over the last decade.

2.3.1. Community Naloxone Distribution

The systematic expansion of naloxone distribution in the U.S. can be traced to: [state laws](#) promoting naloxone access by 2017, [SAMHSA funding](#) for purchase and distribution labor in 2018, [reduced requirements](#) for bulk naloxone distribution by FDA in 2022 enabling [new distribution models](#), [naloxone saturation planning](#) by SAMHSA in 2022, and [over-the-counter status](#) in 2023. State and municipal health departments were also implementing myriad other enabling policies, [technical assistance](#), logistical coordination, and funding.

The U.S. Food and Drug Administration estimated that naloxone distribution in community settings increased from 1.39 million units in 2018 to [16.1 million units in 2023](#), an increase of more than 11-fold. To illustrate the scale, if only half-a-percent (0.5%) of those units reversed an otherwise-fatal opioid overdose, that would represent approximately 80,000 fewer events. The calculation illustrates potential magnitude; actual numbers of deaths averted cannot be inferred from distribution volume alone.

The impact of naloxone distribution depends largely on how effectively naloxone gets into the hands of people who use drugs and others likely to witness an overdose. This is where the work of community organizations becomes consequential: maintaining contact, providing training, replenishing supplies, and supporting people who [repeatedly respond to overdoses](#). Distribution creates the opportunity for protection. Staff of programs and networks of people who use drugs [make that protection real](#).

2.3.2. Expansion of MOUD

Changes in treatment delivery, including easing methadone restrictions, telehealth innovation, long-acting formulations, and Medicaid expansion have broadened opportunities for medication for opioid use disorder (MOUD) since 2018. Low-barrier programs, treatment in carceral settings, and connections from emergency departments to ongoing care create additional points of entry. Many initiatives were [established years ago](#) but were scaled up in the last five. Expansion was motivated by accelerations in overdose rates, and enactment was happening before, during, and after overdose deceleration. Accordingly, it is difficult to draw a direct causal link to the compressed period of rapid overdose decline in 2024, but these programs likely contribute to continuing overdose death deceleration.

The protective effects of methadone and buprenorphine are [well-established](#), with substantially lower mortality during treatment, and conversely heightened overdose risk after treatment cessation. [In Massachusetts county jails](#), receiving medications for opioid use disorder during incarceration was associated with a 52% lower risk of fatal opioid overdose after release. These findings connect specific services to protection during periods of exceptional individual and structural risk.

But expanded opportunities for treatment do not automatically become sustained treatment. [National buprenorphine data from 2019–2025](#) show increased pharmacy availability and emergency-department adoption alongside persistent limitations in initiation and retention. The work of helping someone obtain medication, return after an interruption, or remain engaged despite unstable housing is therefore part of the intervention. Counting prescribers will capture only part of that work. Again, strong personal connections are the most effective, and least documented.

Collectively, policy changes and community-based services created conditions for fundamental reductions in overdose risk by diversifying off-ramps. Although these interventions may take time to make meaningful impact on aggregate overdose rates, their combined implementation could produce benefits that would be difficult to achieve through any one intervention in isolation, and their impact on overdose is likely more diffuse than a tipping point.

As detailed in Section 5, it is a [long-standing challenge](#) to measure the plethora of overdose prevention interventions enacted locally. Even when they are catalogued, as some [opioid settlement spending](#) is, it is difficult to know which specific actions had the greatest impact. For example, [fraud, waste, and abuse of opioid settlement spending](#) are being documented, so analyses only considering remuneration are insufficient. Difficulty measuring interventions should not preclude them from being considered as candidate explanations of overdose trends. We cautioned [two years ago](#) that the causes of the downturn are likely

multiple and difficult to adjudicate. But ease of measurement is a pernicious source of bias that privileges the most isolatable determinants. A group of economists recently termed this the [streetlight effect](#): if our inquiry is driven only by readily available data, then we will only have myopic answers.

2.4. Additional Considerations

We also need to consider the relationship between different explanations. As the preceding sections show, overdose declines began at different times across states and regions. A simple account in which greater intervention resources necessarily produce earlier or larger declines does not adequately explain that geography. The timing of fentanyl's arrival, other changes in the drug supply, and populations reached by services also matter.

Evidence that an intervention protects its recipients does not establish what proportion of the national decline it explains. Naloxone distribution volume is more readily counted than its use at the right moment. Expanded treatment capacity is more readily measured than sustained treatment among people at greatest risk. Interventions may also have prevented deaths while mortality was still rising, with their protection [overwhelmed](#) by a rapidly worsening drug supply. Their existence alone cannot explain the turning point.

These limitations require attention to how interventions and changing conditions work together. A person's dissatisfaction with the drug supply may motivate change; accessible services may help make that change manifest.

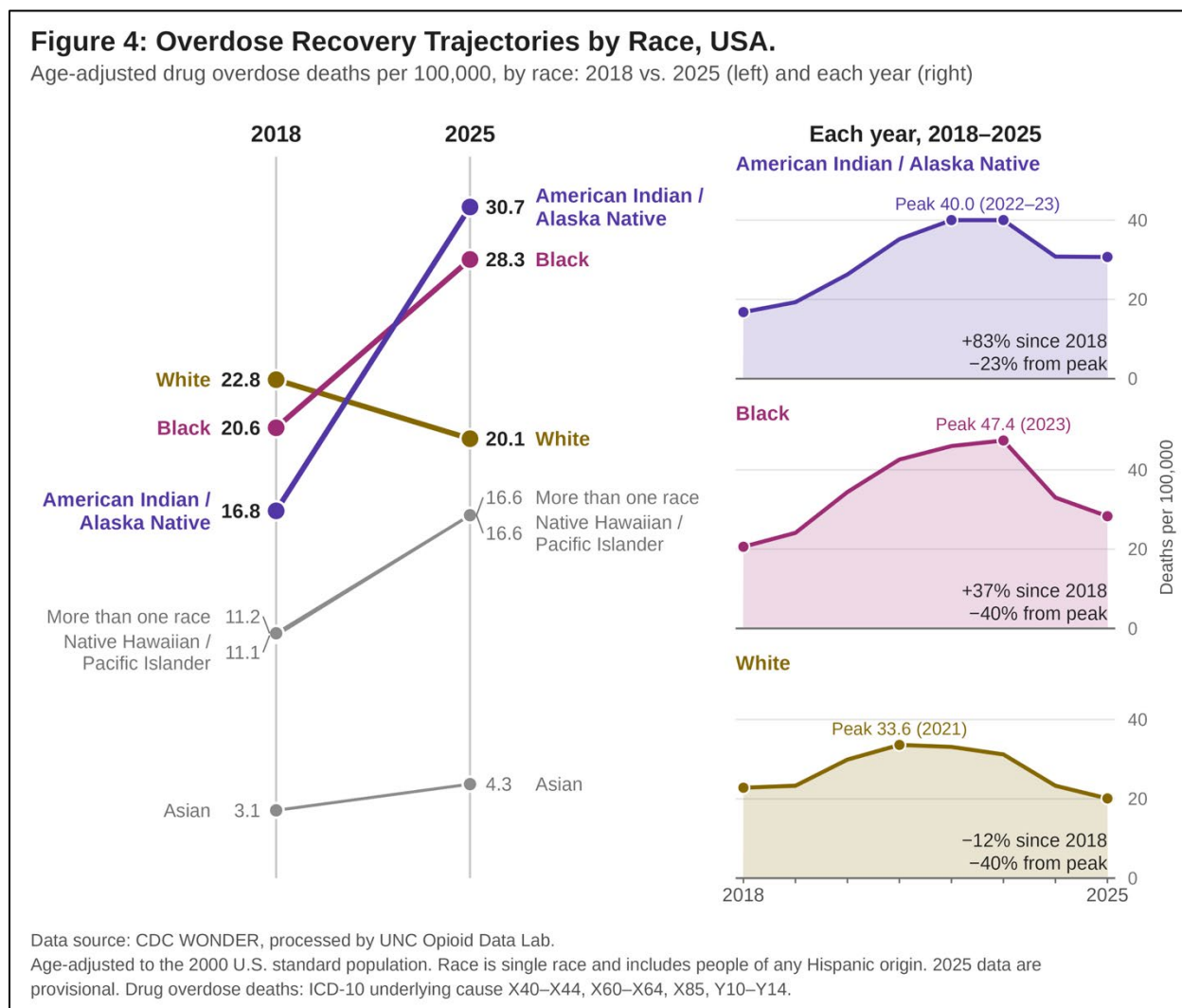
In summary, unwanted adulterants and drug supply changes may motivate a person to reduce use; an accessible medication, service, or self-directed strategy may help them act; and sustained support may help the change endure. The contribution of interventions can therefore extend beyond the moment a service is delivered.

3. Implications for Future Interventions

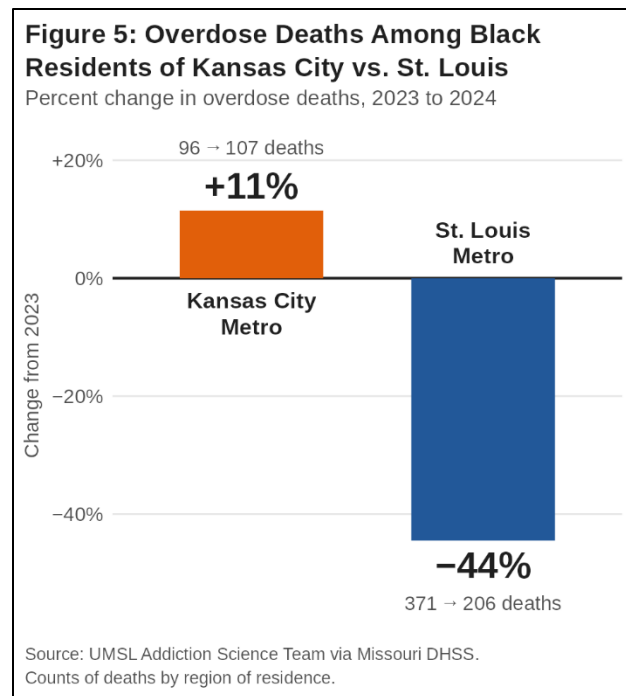
Recent overdose mortality statistics reveal novel demographic shifts. Changes in overdose death rates by race and age illustrate that not everyone is experiencing the same level of overdose recovery, but also point to reasons to hope that recent changes may be enduring and suggest areas for greater investment. At the same time, overdose declines fit into a broader pattern of post-pandemic recovery in well-being.

3.1. Who is Being Left Behind: Racialized Identity

Overdose recovery in some racialized groups has been uneven. Compared to whites, nationally from 2018 to 2025 (Figure 4), age-adjusted overdose rates *increased* among Native Americans (+83%) and Blacks (+37%). While these three races show decline from peak, [Native Americans](#) experienced the shallowest recovery (-23% from peak) compared to whites and Blacks (-40% for both). While African Americans experienced a similar *relative* decline from peak, their overdose rate in 2025 was still +41% *higher* than whites, while for Native Americans it was *higher* by +53%. It is also noteworthy that the peak in overdoses among white Americans was in 2021, while the other two racial identities did not peak until 2023. On national aggregate, we have not returned to pre-COVID levels of overdose mortality, although a [third of states](#) have, including [Kentucky](#). Racial disparities in overdose recovery are a [strong indicator](#) that overreliance on drug supply interdiction and ignoring racial disparities is not effective in reducing overdose rates for everyone. *We still have a lot of work to do.*



A reasonable interpretation of these data is that interventions are not uniformly reaching marginalized communities in the same way as they are helping whites.

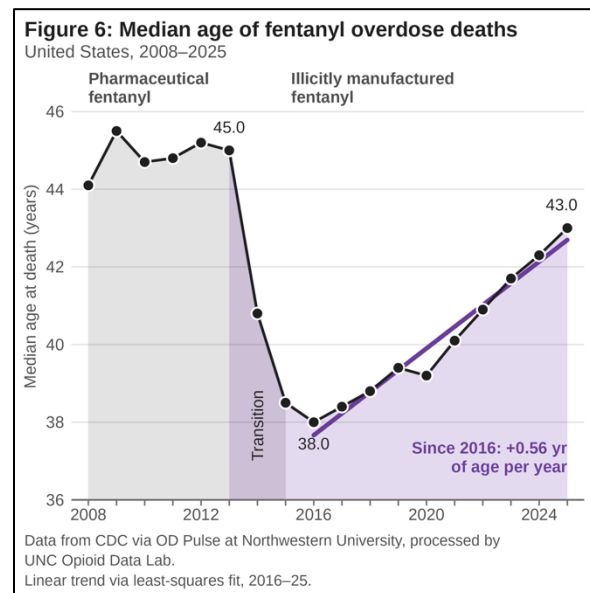


[Vakharia et al.](#) also mention the lack of service penetration among those involved in the criminal justice system, low-income people, and unhoused people. [Access to harm reduction services in Maryland](#) has been shown to be lower among racialized minorities. In a [four-site study](#), compared to whites, use of harm reduction services and substance use disorder treatment were also shown to be lower among Blacks, Hispanics, and Native Americans, from -8.8% to -17.8%. [Similar racial disparities](#) persist in buprenorphine treatment.

The cumulative impact of these systematic disparities is demonstrated (Figure 5) clearly in the two largest metro areas in Missouri. Among Black residents of St. Louis, overdose deaths fell (-44%) from 2023 to 2024, with strong community participation in prevention. The wide scale of interventions deployed (and evaluated) include [naloxone distribution](#), [treatment access](#), and [street medicine](#). In contrast, overdose deaths in Kansas City saw an +11% increase. In Kansas City harm reduction efforts have been heavily constrained by local authorities with limited outreach to Black communities; as a result, Black residents of Kansas City reported carrying naloxone [less frequently](#) than white residents, pointing to systematic intervention inequalities. Even within one state, the risk environments and intervention implementation can differ dramatically.

3.2. Where to Direct Interventions: Age and Generational Patterns

In recent years, fentanyl overdose deaths have shown a pattern consistent with an [ageing birth cohort](#). Each year since 2016 (Figure 6), the median age at death has increased linearly, by 0.56 years. Although this trend alone cannot separate age, period, and cohort effects, it indicates that the population dying from fentanyl overdose is getting older. This is critical for informing policy because education and interventions are often prioritized for youth over age groups that bear the greatest burden.



The concentration of overdose mortality becomes more evident by US birth generation (Figure 7). A key fact: 70% of overdose deaths in 2025 occurred among Gen X and Millennials. Their burden reflects more than the relative size of these generations. In provisional 2025 data, overdose death rates were 36.6 per 100,000 among Gen X and 34.0 among Millennials, compared with 20.8 among Baby Boomers and 8.6 among Gen Z.

These patterns have immediate implications for where interventions should reach people. Preventing initiation among young people remains important, but reducing deaths now requires sustained engagement with middle-aged adults already exposed to years of substance use and changing drug markets. Naloxone, accessible medication treatment, street outreach, housing, and support after incarceration need to reach people in the middle of their lives. Many are also parents and caregivers. Protecting their lives can help preserve the relationships and stability on which younger generations depend.

Notably, Gen Z, aged approximately 13–28 years in 2025, includes young adults in ages when opioid use has historically become established. In [previous drug cycles](#), increasing heroin deaths among younger adults signaled at-risk cohort replenishment. Yet, Gen Z constituted only 9% of overdose deaths in 2025. Substance use trends provide additional

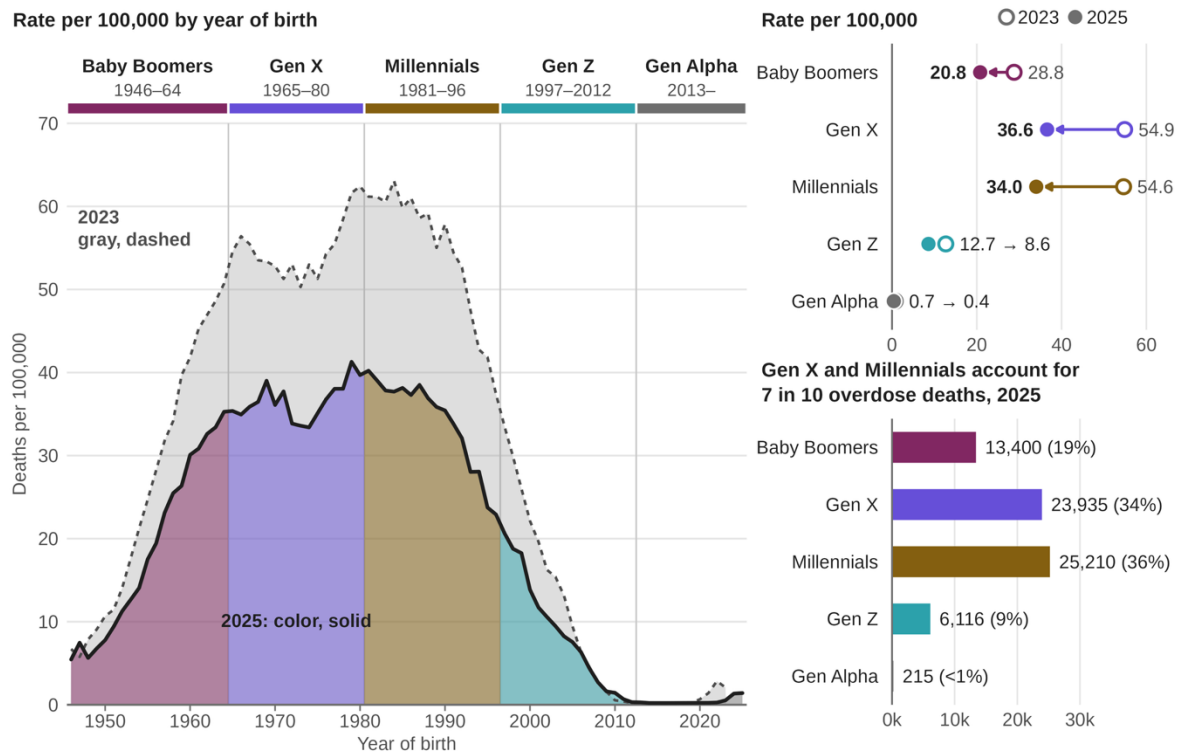
evidence consistent with intergenerational change. According to [NSDUH](#), among adults aged 18–25, past-30-day alcohol use declined from 50.9% in 2021 to 46.2% in 2025, and binge drinking declined from 30.0% to 26.7%. Twenty-something Gen Z's drug tastes have changed away from potent synthetic opioids, and towards less immediately lethal substances: cannabis, ketamine, MDMA, kratom, and psilocybin. In the [2025 NSDUH](#), past-30-day cannabis use was highest among adults aged 18–25, at 23.3%, compared with 14.9% among adults aged 26 and older. [If fewer young people](#) refrain from sustained harmful opioid use, reduced replenishment of the population at risk could help make overdose declines enduring. After 30 years and multiple affected generations, these changes are encouraging.

Beyond prevention, emerging research indicates that younger adults today [feel less stigma](#) in disclosing substance use disorders and are more [comfortable](#) seeking help than older generations. [Generational differences](#) have been shown with help-seeking for alcohol use disorder, including specific generational preferences for types and [styles](#) of treatment. In the long term, destigmatizing help-seeking is a positive benefit that could break the decades-long intergenerational cycle of overdose risk cohort replenishment.

These encouraging patterns should not obscure differences within generations. An [analysis comparing 2022 with 2024](#) identified increases in overdose deaths among the younger birth cohort born from 2005 to 2011, even while deaths declined among older Gen Z. These young people experienced pandemic disruptions during formative periods of adolescence. This cohort may become a harbinger of future opioid cycles if their needs are not addressed directly.

The policy implications are that prevention messaging and interventions should be [tailored to age group](#) and changing patterns of substance preference. Resources should reflect both where deaths are concentrated now and where new risks are emerging. So too must harm reduction, as a field, adapt to the needs of a younger generation, making space for new methods to keep themselves safe.

Figure 7: Overdose Rate Changes 2023 vs. 2025



Data from CDC WONDER, processed by UNC Opioid Data Lab.
Drug overdose deaths (ICD-10 X40–X44, X60–X64, X85, Y10–Y14); 2025 is provisional. Birth year = year of death – age at death. Generations per Pew Research Center.
Suppressed counts (1–9 deaths) set to 9, so Gen Alpha rates are upper bounds. The Silent Generation (born 1928–45) is not shown. Shares are of all 69,458 overdose deaths with a stated age in 2025, including 555 Silent and 27 Greatest Generation deaths.

3.3. Social Changes After the Pandemic

Overdose declines have coincided with socially positive trends in other indicators, including declining [violent crime](#), [motor vehicle fatalities](#), and [suicide mortality among adolescents and young adults](#). Overdose mortality increases and decreases are [correlated](#) with macroeconomic indicators—consumer price inflation and consumer sentiment—that shared pandemic-era temporal patterns but had no pharmacological pathway to overdose death directly. (We have [previously highlighted](#) the economic determinants of drug use problems.) Given the evidence of COVID-era impulses on overdose mortality increases presented in Figure 2, there is reason to expect that overdose declines may also be linked. While the timing and distribution of these indicators differ, these parallel improvements are consistent with a [broader social recovery globally](#), including improvement in mental and physical well-being and reduced isolation from the pandemic era. They provide context for understanding overdose declines, although establishing their causal connection remains methodologically elusive.

4. What Is Not Likely Reducing Overdose Rates

In contrast to the factors above, some additional suggested contributors are not likely to be contributing directly to the decline in overdoses.

Extra-judicial boat strikes in the Caribbean and Pacific by the US military starting in 2025 were rhetorically intended to reduce fentanyl trafficking, but instead targeted cocaine distribution routes and people not involved in drug transport. [Multiple analyses](#) including [by DEA](#) have suggested that cocaine flows to the United States have not changed, while [straining multi-national cooperation](#) on interdiction of large criminal organizations. [Stimulant involvement](#) in overdose deaths has increased proportionally recently.

Other efforts can be counterproductive. The track record (Figure 1) of criminalizing drug possession with the sustained “War on Drugs” was unable to prevent a 20-fold increase in the rate of drug deaths. From [San Francisco](#) to [Indiana](#), street level drug seizures are known to [immediately increase overdose](#) within a few city blocks. [Drug-induced homicide laws](#) have also been shown to be inadequate deterrents. Good Samaritan Laws have had some [benefits](#), but [calls to 911](#) for overdose have plummeted with naloxone saturation. While these interventions may be ostensibly well-intentioned in the name of public safety, their direct impact on the decline in overdose deaths is likely minimal.

While GLP-1 medications show [short-term relative reductions](#) in alcohol consumption, their impact on population level would be limited given differing patient populations and high numbers needed to be treated to prevent one overdose fatality.

There is [speculation](#) that the increased presence of counterfeit pills, which have [lower fentanyl quantity](#) per unit than powder baggies, could stabilize opioid tolerance and lead to fewer overdoses. Yet, [two-thirds](#) of law enforcement drug seizures are in powder form nationally, except in the West where they are only a quarter. More alarmingly, states with the highest penetration of fentanyl pills ([Arizona, Colorado, New Mexico](#) greater than 95% of fentanyl seizures) are some of the only states with considerably [increasing overdose deaths](#) in 2026.

Finally, [multiple authors](#) have suggested that overdoses dropped because of the nihilistic idea that “there is nobody left to die,” the epidemiological concept of depletion of susceptibles. It is worth reiterating that since peak in the Summer of 2023, an additional quarter million people have died of overdose. The suggestion that there is nobody left to die is clearly untrue, and insulting to acutely grieving families. More compassionately, the same concept could be applied to people choosing to cease illicit opioid use long-term due to myriad individual reasons, thereby removing them from the at-risk pool. This may be the case especially with the youngest adult generation and as a result of dissatisfaction with the drug supply.

5. Threats to Continued Improvement

The aforementioned uptick in overdose in 2025 demonstrates that the current recovery is fragile. Sudden changes in the unregulated drug supply are always possible. In the historical scale of drug outbreaks, the sudden intensification of deaths due to illicitly manufactured fentanyl since 2020 is of moderate tenure; it will be years before it becomes apparent if it is an early wave of a synthetics era or an anomaly. In the short-term, beyond drug supply, two other factors threaten enduring progress: funding cuts and a decimated frontline workforce.

First, [defunding](#) effective public health and clinical programming is shortsighted. Serial federal funding and staffing cuts across Health and Human Services agencies in 2025-26 takes the wind out of the sails just as recovery is picking up speed. Medicaid is the [largest payer of addiction treatment](#) services in the nation, yet eligibility is threatened. Citing overdose declines, county opioid settlement commissions are [being disbanded](#). In parts of the West, where [fentanyl displaced heroin later](#), overdoses are [beginning to ease](#). In that region and beyond, the conflation of housing insecurity and public drug use has translated into reallocation of funding, with the expectation that police be the primary actors in overdose prevention. Yet, it is unfair to law enforcement to expect them to solve complex intertwined problems of [homelessness](#), mental health, and addiction with only handcuffs, as rising overdose deaths [in jails](#) demonstrate. Much of recent years' advance seem on the brink of dissolving, just when expansion could support a multi-generational break in the cycle of overdose increase.

The second threat flows from funding cuts: The frontline workforce directly reaching people with substance use disorders is undergoing [major contractions](#). Chronically undervalued outreach workers and program staff face existential financial stress nationwide, depriving us of exactly the expertise needed to reach people at greatest risk of overdose. Via the UNC Street Drug Analysis Lab and [Remedy Alliance For The People](#), we also observe that the frontline workforce is exhausted and demoralized. Years of grief and constant funding instability are taking an emotional toll. They too are being asked to solve major societal problems beyond their control. Harm reduction programs and the people they serve are the "last mile" in overdose prevention; there is no more efficient way to get naloxone into the hands of people who will actually use it.

6. Synthesis

Fentanyl and fentanyl analogues were part of the American drug supply in the Northeastern United States by the mid 2010s. A fentanyl production ban in China in 2018 created an opportunity for nearshoring fentanyl production to México, driving diversification by and competition between large drug producing organizations. The isolation and social trauma

brought on by the COVID pandemic led to an increase in demand for psychoactive substances, and using alone. Unregulated fentanyl filled this demand when global trade ground to a halt. Waves of overdose mortality acceleration, corresponding to major coronavirus variants in the United States, led to incrementally increasing impulses cresting in historically unprecedented overdose mortality, especially in regions with established fentanyl distribution channels. As unregulated fentanyl displaced heroin, in an east-to-west pattern, people who use drugs changed behaviors to cope with unregulated fentanyl as the pandemic wore on, including normalization of naloxone carriage and avoidance strategies. Adaptation is not instant, and the geographic procession of fentanyl led to observable waves of increasing overdose deaths by broad region (e.g., Western US) where fentanyl had not been dominant. Less documented were impulses of risk penetrating micro-clusters of people who use drugs together, those who had been heretofore insulated from fentanyl exposure perhaps.

By 2023, inter-cartel competition and arrests of high-level drug trafficking network leaders splintered upstream fentanyl supply. As a market correction to reduced availability of fentanyl, American drugs became characterized by heavy adulteration with xylazine, numbing agents, BTMPS, and medetomidine, accelerating in early 2024. These additives carried additional health harms, but were less immediately lethal. The resulting dissatisfaction with the opioid supply led people to seek off-ramps for their use, capitalizing on the newly expanded treatment infrastructure and individual decisions to use less, less often, or cease use. The return of heroin in the West, and other quasi-legal opioid alternatives allowed those unwilling or unable to access treatment to find fentanyl-avoidance options, along with major changes in routes of administration. Collective behavioral adaptation to fentanyl became the norm in places where fentanyl had been around longer. As fentanyl more completely replaced heroin, unregulated fentanyl became less of a contributor to attributable mortality.

That off-ramps existed was the consequence of expanded public health interventions, buoyed by the earliest distributions of opioid settlement funds. Pandemic-era federal relaxation of drug treatment and antidote distribution regulations, over-the-counter approval of and systematic funding for naloxone, including saturation plans, were implemented nationwide. Expansion of drug treatment was enacted through telehealth, low barrier models, long-acting formulations, Medicaid expansion, and implementation in carceral settings. Combined with a less immediately lethal drug supply, by mid-2024 there was a massive deceleration in overdose deaths in most of the nation, less pronounced in places where fentanyl had more recently displaced heroin.

These positive changes were made enduring by age-related shifts among coming-of-age young adults in Gen Z, whose drug tastes shied away from illicit opioids, driven in part by expanding cannabis availability. Overdose mortality is becoming concentrated in middle-

aged Millennials and Gen X. Yet, by 2021-2, rates of fentanyl-related mortality among Native American and African Americans eclipsed traditionally higher mortality rates among whites, suggesting that the age trends have been countered by the expansion of the fentanyl user base. If resources can be invested in these communities, and if social conditions improve as the pandemic recedes further into the past, further declines should be possible.

But these trends are not inexorable. In late 2025, certain areas saw an increase in retail fentanyl concentrations as new manufacturing capacity came online in México, due to defections from ageing and splintering cartel loyalties. Adulteration is one dimension of the changing drug supply, but so are sporadic influxes of novel synthetic opioid classes (nitazenes, orphines, methadone analogues). While these have garnered attention, they are a long way from displacing unregulated fentanyl or heroin. Increasing indicators of stimulant involvement in mortality raise new concerns. Drug harms beyond overdose (e.g., HIV, hepatitis, abscess, life-threatening withdrawal) will become more relevant as overdoses continue to decline, requiring recalibration of data systems and intervention offerings.

7. How we know what we know

Overdose mortality data

Overdose death data arise at the local level, in hospitals and from investigations by coroners and medical examiners. Local death records are aggregated by state vital statistics offices, and sent to CDC as literal death certificates. For all deaths, CDC uses software to assign a standardized alphanumeric code (ICD-10) for the cause of death, separating intentional and unintentional deaths. These data are delayed by 2-3 years. For overdose deaths in particular, CDC maintains a separate system (by NVSS) that adjusts overdose deaths for historical delays in reporting, creating predicted estimates for more timely data, lagging about 8 months.

Drug supply data

Law enforcement drug seizure data arise from municipal and state crime labs, and are supported by federal field labs maintained by DEA. Federal Customs and Border Control records drug seizures at international borders and ports. These data are primarily intended for prosecution, and are biased towards controlled substances that carry stronger criminal penalties; additives that may have health harms are systematically excluded. In addition, over 200 public health drug checking programs analyze donated drug samples from people who use drugs, returning results quickly to individuals along with tailored advice on avoiding harms. These are the most complete data on the drug supply and represent retail level exposure, and including fillers, cuts, and psychoactive substances; analytical chemistry data can be qualitative or quantitative. Data from urine drug testing can supplement these

findings, along with emergency department data of toxicology screens. These data sources use validated panels and report a limited number of biologically active substances of greatest importance to clinical management. Wastewater testing is primarily conducted via one commercial company in about 100 sites, usually sampling municipal sewage systems 2 days per month, and screening for a limited set of pre-defined substance, providing qualitative or quantitative findings. At the current time, there is [no established method](#) for generalizing drug supply findings to an entire nation.

Intervention data

Nationwide intervention data are among the most difficult data to collect systematically. No universal database documents the immense volume of interventions enacted to prevent overdose deaths over the last decade. State-level databases on opioid settlement spending provide additional information, but are not ubiquitous or standardized. For specific interventions, pharmacy dispensing, program records, and reported overdose reversals provide useful information. None fully captures who was protected, for how long, or what became possible through repeated contact.

Along a different epistemological pathway, if you know the names of individuals whom you have repeatedly helped with their substance use or consequences, you can readily observe individual improvements. Establishing causal effects requires additional attention to what would have happened without the intervention.

Policy and intervention analyses aggregating data to large geographic areas often lack information on individual-level receipt of services, and thus rely on collective measurement proxies. A policy's adoption does not establish that everyone in that geographical unit was exposed to the intervention at the same level, or that implementation was measured consistently. Drawing individual-level conclusions from aggregate associations can introduce [inter-level bias](#), including the "ecological fallacy." A [perennial problem](#) in observational research, this requires particular care in a complex multi-causal situation.

These measurement gaps limit attribution in both directions. They leave much of the work of direct service providers uncounted, while also preventing confident estimates of their contribution to the national decline. Better documentation of actual service receipt, sustained engagement, and changes in exposure would help connect what providers observe with what population analyses can explain.

8. Conclusions

The tragic increase in overdose deaths during the COVID pandemic is one of the greatest failings of public health and public safety in American history. In hindsight, a public inured to decades of unrelenting overdose increases, and suffering from economic distress and social upheaval, could not stop the maelstrom. The subsequent overdose declines, as

welcome as they are, only bring us back close to pre-pandemic baseline. Rates that were alarming then are just as alarming now. The nature of risk and recovery has evolved considerably over the last six years, with many positive health and social supports. These changes can be made enduring if our attention remains on embracing effective solutions, focusing on those with the highest mortality rates, and avoiding overly simplistic explanations for the overdose decline. Many of us do the work of overdose prevention because faith and moral duty compel us, suffused with grief. Yet, we continue still to lose too many people we love. Our work must continue; it is incumbent upon us to honor their memories and invest in the workforce, infrastructure, and policies that offer humane futures.

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Use of Generative Artificial Intelligence (AI)

All text was written by me, a human. Claude Opus 5.5 (Anthropic, Inc.) was used to generate R code for figures. Chat GPT-6 Astra and Sol 5.6 (OpenAI, Inc.) were used to compile hyperlinks into a reference list. All AI-assembled content was subject to human review.

Reference List

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