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POLICY ARTICLE

DRUG POLICY

Did the illicit fentanyl trade experience a supply shock?

A synthesis of government and social media data suggests a disruption, possibly tied to events in China

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Fatal overdoses from synthetic opioids, most notably fentanyl, steadily increased more than 25-fold in the United States over 15 years, peaking at 76,000 in 2023 (*1*). This trend began to sharply reverse in mid-2023, dropping the annual rate of fentanyl overdose deaths (ODDs) by over a third by the end of 2024 (*1*). Explaining this unexpected drop is of major scientific and policy interest. Whether a supply shock could account for a substantial part of the decline is challenging to determine because drug trafficking organizations operate in secret. Synthesizing data from the US and Canadian governments and from discussions on the social media platform Reddit, we suggest there was a major disruption in the illicit fentanyl trade, possibly tied to Chinese government actions, that translated into sharp reductions in overdose mortality beginning in mid- or late-2023 and continued into 2024 across both the US and Canada.

Supply shocks sometimes produce large and rapid changes in the severity of drug problems. The early proliferation and overprescribing of prescription opioid pain medications beginning in the late 1990s and traffickers' introduction of fentanyl into the North American illicit drug supply around 2014 are two prominent examples of supply changes that sharply increased drug-related morbidity and mortality (*2*). In the opposite direction, the pronounced drought in Australia's heroin supply in early 2001 (the causes of which are still debated) was followed by a 60% decline in opioid overdose mortality (*3*). The Chinese government's scheduling of the potent synthetic opioid carfentanil in 2017, legally designating the drug as potentially dangerous and tightening regulatory controls on it accordingly, immediately preceded a sharp drop in both seizures of and deaths from this fentanyl analog in the Midwest US region where it was prevalent (*4*). Controls on precursor chemicals used in the manufacture of drugs can sometimes shock markets; increased controls on pseudoephedrine, required to make methamphetamine, reduced availability and harm from that drug for at least some months (*5*).

CONVENTIONAL INDICATORS OF DRUG SUPPLY AND ITS RELATIONSHIP TO PUBLIC HEALTH

We begin with two standard indicators of drug supply: drug purity and counts of seizures of drugs by law enforcement. Drug dealers often adapt to supply shortages by lowering purity more than raising prices. This is akin to the "shrinkflation" seen in many consumer products in recent years. Documented historical examples include European and Australian heroin markets (*6*), and US methamphetamine markets (*7*). Lower purity may translate into fewer deaths if overdose risk is greater with drugs that contain more instead of less fentanyl.

In its 2025 *National Drug Threat Assessment*, the US Drug Enforcement Administration (DEA) provided estimates of the average purity of seized fentanyl (powder and pills separately) for each month from January 2019 to October 2024 (*8*). We consider these data alongside monthly US. ODD rates involving synthetic opioids indexed to May 2023, when monthly ODDs were at their peak (see the first figure).

Purity and ODD rates both turned down at roughly the same time. In particular, the purity of fentanyl powder rose sharply in 2022, cresting around 25% by weight from March to July 2023, but then fell by more than half by the end of 2024 to ~11% by weight. Likewise, by the end of 2024, the monthly rate of ODDs involving synthetic opioids had declined by more than half from their May 2023 peak. The average purity of fentanyl pills also fell, albeit slightly less (by one-third, to roughly 1.5%) and slightly later than the decline in powder purity and deaths.

The correspondence is broader than just those downturns. Across the entire monthly series from January 2019 to October 2024, the rate of synthetic opioid ODDs was correlated with the purity of fentanyl in the form of both pills [correlation coefficient r = 0.62; 95% confidence interval (CI): 0.44 to 0.74] and powder (r = 0.37; 95% CI: 0.15 to 0.56) (see the first figure).

The number of drug seizures tends to positively correlate with supply. Semiannual counts of fentanyl seizures reported publicly by the US National Forensic Laboratory Information System (NFLIS) peaked in the first half of 2023, fell by 15% in the second half of 2023, and were 37% below peak by the second half of 2024 [see supplementary materials (SM)]. In theory, seizures could have fallen despite stable supply if enforcement ebbed. However, given the sustained public and political attention to the fentanyl crisis throughout this period, reduced supply seems the more plausible explanation for declining seizure numbers.

AN UNCONVENTIONAL INDICATOR OF ILLICIT DRUG SUPPLY SHOCKS

Another avenue for attempting to determine whether a supply disruption took place is to gather data from customers. Given the challenges of recruiting persons purchasing illegal drugs to participate in research and the more general difficulties of tracking drug problems in real time, some researchers are finding productive uses for social media postings as drug problem indicators (*9*).

In particular, Reddit participants frankly discuss drug availability and quality. We therefore analyzed Reddit posts containing the word "fentanyl" (including misspellings and slang terms such as "fetty") across six subreddits: r/fentanyl, r/heroin, r/opiates, r/meth, r/cocaine, and r/mdma. Within these posts, we tracked mentions of the word "drought" (and similar terms, such as "shortage") monthly from January 2021 through January 2025. We then manually verified that drought references pertained to fentanyl availability rather than other contexts.

These Reddit data show a first notable peak in mention of drought in July 2023, followed by a much more pronounced spike beginning in late 2023 and continuing until it was cut short by moderator intervention (see the second figure). In January 2024, the r/fentanyl subreddit moderator temporarily banned drought-related posts on the theory that it violated site principles regarding drug-related discussions. By July 2024, the ban's effect seemed to have diminished, and drought mentions were again far above baseline levels and remained so through the end of 2024. The Reddit data suggest perceived supply shortages beginning in the middle of 2023—roughly coinciding with the beginning of the decline in fatal overdoses (see SM).

AN INTERNATIONAL COMPARISON TO DETECT THE SOURCE OF THE FENTANYL SUPPLY SHOCK

Like the United States, Canada has faced a serious fentanyl overdose challenge, but—according to a widely held view (see SM)—with an important and clarifying difference in its supply chain. It is widely believed that illegal fentanyl in both Canada and the US ultimately derives from

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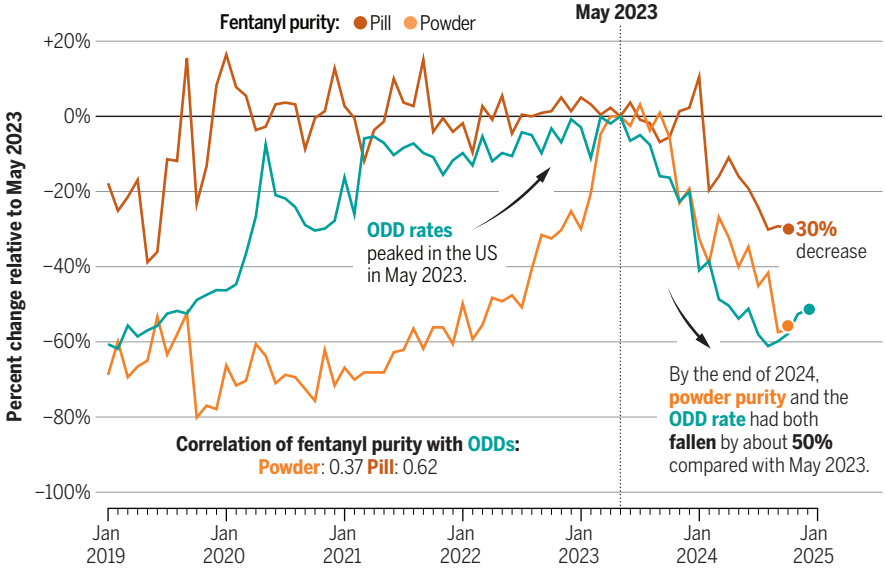
imported precursor chemicals, primarily sourced from China. However, increasingly after 2019, in Canada those chemicals are synthesized into fentanyl by domestic traffickers, rather than in Mexico, as occurs with the US fentanyl market. Furthermore, fentanyl flows across the US-Canadian border appear to be small compared to US imports from Mexico or Canadian domestic production. Interruptions in the flow of precursor chemicals might therefore affect Canadian fentanyl indicators at roughly the same time as US indicators. However, if the US reduction stemmed primarily from US or Mexican interventions with fentanyl itself, or from conflicts or collusion among fentanyl suppliers in Mexico, we would not expect this to have a substantial impact in Canada.

Canadian national fentanyl-specific ODD data are reported annually, making it hard to detect a mid-year decline. However, quarterly data are available for deaths from all opioids overall. More than 80% of these deaths are fentanyl related. Therefore, a downturn in Canada's quarterly opioid deaths likely reflects declining fentanyl deaths (see SM for details about all data and analyses regarding Canada). Canadian opioid ODDs begin to decline in the third quarter of 2023. Three related indicators (emergency medical service responses to suspected opioid poisonings, total opioid-related hospitalizations, and total opioid-related poisoning visits to hospital emergency departments) show similar trends.

US fentanyl purity and overdose mortality rates

Rates of overdose death (ODD) involving synthetic opioids and the purity of fentanyl powder and pills are indexed to May 2023, when ODDs peaked in the United States. Crude ODD rates are calculated using monthly population counts. See supplementary materials for details.



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The average purity of lab-analyzed fentanyl powder samples in Canada did not drop until late 2024, but it became increasingly volatile starting in early to mid-2023. The number of identifications of fentanyl in lab-assayed samples fell throughout 2021–2024. That decline was offset by increases in fentanyl analogs—something not observed in US NFLIS data. Although national data are mostly reported quarterly, the province of British Columbia reports monthly data. That province is of particular interest because it both plays a leading role in Canadian fentanyl supply and is where fentanyl hit earliest and hardest. ODDs there dipped in August and September of 2023 but did not fall sharply until October 2024.

Overdose deaths began to fall in both the US and Canada overall around mid-2023, although the decline in British Columbia came later (see table S1 for a summary across available indicators). Multiple US supply-side indicators are consistent with a disruption in fentanyl supply in mid- to late-2023. Supply-side indicators from Canada are consistent with constrained supply at that time but do not show abrupt shifts. One of those indicators (a shift from fentanyl to fentanyl analogs) manifests in Canadian but not in US data, hinting that although both markets' supply may have been constrained at the same time, the two markets were distinct enough to adapt in somewhat different ways.

POLICY IMPLICATIONS

It has been said that "success has many fathers" and supporters of various types of interventions—including treatment, harm reduction, and domestic law enforcement—have wished to be associated with the sizable and welcome reductions in ODDs. Yet, multiple indicators are consistent with a major disruption in the illicit fentanyl trade that translated into sharp reductions in overdose mortality beginning in mid- or late-2023 and continued into 2024 across both the US and Canada. Inasmuch as both countries were affected, actions by the government of China that resulted in greater scrutiny of production and export of precursor chemicals, including the removal of online advertisements and several marketplaces, are candidates for explaining these parallel mortality declines (see SM). Another possibility is that US interventions in Mexico disrupted US supplies and concurrently and separately other events disrupted Canadian supply. However, given the incentives for government officials to claim credit for positive outcomes, it is noteworthy that the US Drug Enforcement Administration (DEA) in its *2025 National Drug Threat Assessment* (published in May 2025) did not stress its own role in creating the disruptions. Rather, it observed: "Fentanyl purity declined throughout 2024, consistent with indicators that many Mexico-based fentanyl cooks are having difficulty obtaining some key precursor chemicals. DEA reporting indicates that some China-based chemical suppliers are wary of supplying controlled precursors to international customers, demonstrating awareness that the Chinese government is controlling more fentanyl precursors to comply with recent updates to the United Nations counter-narcotics treaty" [(*8*), p. 23].

Though the government of China only episodically reports its enforcement and regulatory activities, there is considerable evidence of actions against fentanyl precursor manufacture and export in late 2023. For example, in November 2023, China's Office of the National Narcotics Control Commission published a notice reminding caution in the selling of substances that can be used to make drugs. At the same time, the government of China began more aggressive law enforcement action against synthetic drug and chemical precursor suppliers. By June 2024, the government claimed to have taken down 140,000 advertisements and 14 online platforms. A November 2023 meeting between Presidents Biden and Xi led to increased drug enforcement cooperation between the two countries. Many observers see China as taking advantage of an asymmetry in the two countries' interests in the synthetic opioid problem. The United States is very concerned about fatal overdoses associated with the drug. For China, domestic opioid abuse is a negligible issue, as are the financial stakes in selling fentanyl or its precursors to North America. It can choose to increase control efforts at little cost in return for substantial US concessions on other issues.

These findings have three implications if the decline in deaths came from a supply disruption, regardless of the source of that disruption. The first is that effective drug supply control need not involve large-scale arrests of retail drug dealers, which did not happen at this time the way it did in the US in the 1980s and 1990s. That is heartening because street-level enforcement can result in large and racially disproportionate increases in incarceration while at the same time there is

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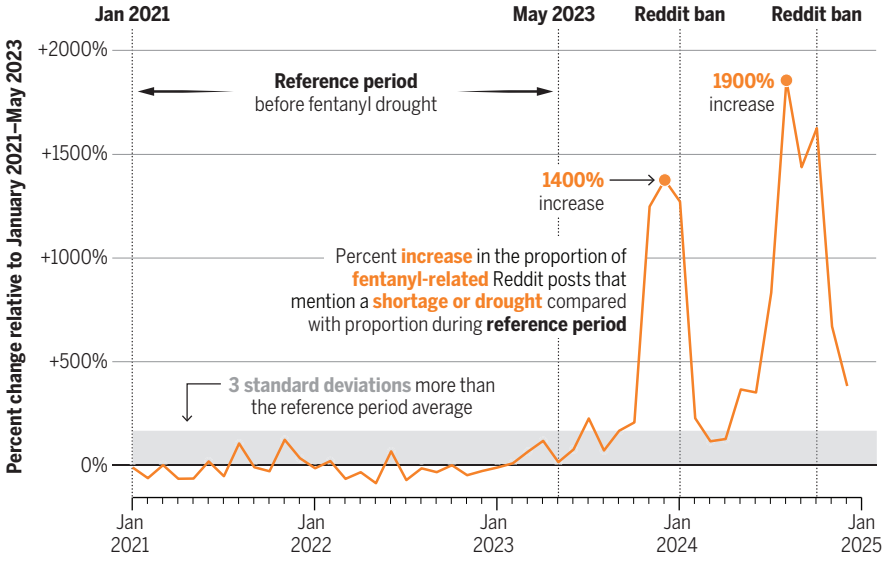
Reddit posts reflect discussion of fentanyl drought

Of the total fentanyl-related Reddit posts each month, the proportion that mention "drought" are shown, relative to the mean during the reference period spanning January 2021 through May 2023. Discussion moderators twice enforced bans on fentanyl drought–related posts.



little evidence that tougher domestic enforcement, either at the street level or at the wholesale level, can make drugs more expensive or make them harder to acquire.

Second, the good news may not last. As with various rounds of methamphetamine precursor controls, trafficking organizations may adapt to supply shocks over time (*5*). For example, if the disruption pertained to precursors in this case, trafficking organizations may harden their operations against further interdiction, by maintaining larger stores of fentanyl and precursors or creating backup routes of production.

The incentive to restore the illicit fentanyl trade will persist as long as there is demand for the drug. So, a third implication is that it may be wise to use the current drought as an opportunity to ramp up the prevention and treatment programs that have evidence of decreasing demand (*10, 11*).

A further implication pertains if Chinese actions were indeed a major contributor to the sharp declines in US and Canadian ODDs: Diplomatic efforts could yield appreciable returns. Policy-makers might also engage with other existing and potential precursor-producing countries, particularly India, whose drug suppliers are of growing concern to law enforcement agencies (*12*). More generally, international cooperation on supply control may sometimes usefully complement domestic efforts.

LIMITATIONS AND FURTHER WORK

Like all studies of national policies, our analysis has no randomization to condition, meaning at least theoretically that some unmeasured change within the US and Canada coincident with Chinese precursor controls may have produced the patterns that we observed. Because only three countries have a fentanyl-dominated illicit drug market (the other being Estonia), we cannot assume that any of the apparent impacts of precursor drug interdiction would hold elsewhere if more nations develop a fentanyl use problem or an illicit fentanyl industry.

Further, data on purity measures are not specific to seizures obtained at the retail level. This is most important for powder samples, which likely include more pure wholesale samples obtained higher up in the supply chain. Variation over time in the proportion of analyzed samples from retail versus above-retail market levels could affect the average purities reported here.

The waning of the COVID-19 epidemic is another candidate explanation for sudden declines in ODDs. US overdose mortality soared by 30% in 2020 and a further 15% in 2021 (*2*). If COVID-19's presence increased ODDs, its retreat presumably reduced them. However, the timing argues against this being the primary explanation. The decline in ODDs began in 2023, more than a year after the last large peak of COVID-19 deaths in early 2022 [21,350 deaths the week of 22 January 2022, falling by 94% over the ensuing 3 months (*13*)]. Furthermore, the increase in ODDs in 2020 was in part a rebound from a trough in 2019—the last time China took strong action against fentanyl supply.

Our limited data suggest that actions in China offer one plausible explanation for the fentanyl supply shock. We recognize that drawing inferences about Chinese government policy is inherently speculative given its lack of transparency (*14*). As a final note, this analysis reveals critical data gaps that warrant attention. Developing and deploying more systematic methods for monitoring illicit drug supply chains, including real-time purity tracking and enhanced social media surveillance, could improve the ability of law enforcement and public health authorities to detect and effectively address future supply shocks. □

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SUPPLEMENTARY MATERIALS

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