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# The Post-Fentanyl Urbanization of the Opioid Epidemic

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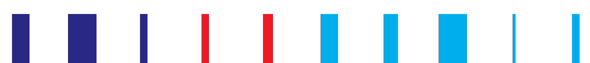

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# The Post-Fentanyl Urbanization of the Opioid Epidemic*

## Abstract
The geography of the U.S. opioid epidemic has shifted repeatedly across epidemic waves. After a period in which overdose mortality increasingly burdened rural and suburban communities, the fentanyl era appears to have redirected the crisis toward dense urban cores. Here, we document a post-2015 urbanization of overdose harm using national mortality microdata from CDC WONDER (1999–2021) and inpatient discharge records from Pennsylvania (2015Q4–2025Q1). We show three patterns. First, urban overdose mortality rises sharply after fentanyl becomes the dominant illicit opioid. Second, within large metropolitan areas, overdose rates diverge between core counties and suburban peripheries, with especially pronounced gaps in eastern metros where fentanyl diffused earlier and more intensely. Third, within the Philadelphia region, overdose-related inpatient admissions become increasingly concentrated in a small number of central-city ZIP codes, especially around longstanding drug-market hotspots. We argue that this reorientation reflects both supply and demand-side changes associated with fentanyl: its high potency lowers transportation costs and favors retail agglomeration, while faster and more severe withdrawal encourages consumption closer to the point of purchase. These findings have immediate policy relevance. If overdose risk is becoming more spatially concentrated, then enforcement, naloxone distribution, outreach, and emergency response may be more effective when targeted to a narrower set of urban locations.

## JEL classification
I18, K42, I10, R11

## Keywords
fentanyl, overdose, opioid, drug epidemic

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* Declarations of interest: none

# 1 Introduction

Significant disparities in mortality rates across U.S. geographies have emerged since the 1990s, which can partly be explained by "deaths of despair" such as suicide, alcohol-related liver diseases, and drug overdoses (Case & Deaton, 2020; Couillard et al., 2021). In the wake of the opioid epidemic, drug overdoses in particular have become the leading cause of death for Americans aged 18 to 45 (CDC, 2025). Drug overdose mortality rates per capita have varied considerably across U.S. geographies since the epidemic's first wave began in the 1990s. While long viewed as an urban social problem, opioid overdoses had become increasingly common in rural and small towns in the Midwest, Appalachia, and New England by the 2000s due to higher rates of opioid prescribing than in major metropolitan areas (Guy et al., 2017; Garcia et al., 2019). The epidemic's second wave started around 2010 with a switch from prescription pill to heroin consumption due to a simultaneous increasing supply of heroin to metropolitan drug markets and a decreasing availability of prescription painkillers due to policy measures designed to reduce prescription access. The opioid epidemic's most recent third wave began in the mid-2010s with the proliferation of fentanyl, a highly-potent synthetic opioid, which has led to a nationwide surge in overdoses disproportionately borne by urban centers of major metropolitan areas.

In this article, we document a geographic reorientation of the U.S. overdose crisis to the urban core in the post-2015 period after the rise of fentanyl as the primary illicit opioid in the United States. After a decade in which overdose mortality increasingly burdened rural and suburban communities, the fentanyl era is characterized by renewed concentration in urban areas and, within large metropolitan regions, in dense central-city cores.

Using national mortality microdata from CDC WONDER (1999–2021) and PHC4 inpatient discharge records from Pennsylvania (2015Q4–2025Q1), we find:

- A post-2015 surge in urban drug overdose deaths.
- Within large metropolitan areas, a sharp rise in core-county overdose rates compared to metro peripheries (suburban counties) from 2016-2021.
- A more pronounced urban core-suburban divergence in overdose deaths in major metropolitan areas east of the Mississippi River, where illicit fentanyl was introduced earlier and more intensely.
- Within the Philadelphia metro area, increasing spatial concentration of inpatient overdoses into a small set of central-city ZIP codes between 2017 and 2024.

We interpret these patterns through a simple economic mechanism: fentanyl lowers effective transportation costs (via potency and weight-to-value), raising the relative importance of fixed risk-management costs and inducing retail agglomeration; simultaneously, faster onset and greater severity of withdrawal increase urgency and encourage use closer to the point of purchase. Together these forces imply that overdoses—which track consumption—become increasingly clustered in urban cores.

# 2 The Shifting Geography of the Opioid Epidemic

## 2.1 The First Wave (Prescription Pills)

The opioid epidemic of the 1990s-2010s precipitated a shift in the demographic composition of opioid users in the United States. A six-decade study of treatment center patients analyzed by Cicero et al. (2014) indicates that in the 1960s and 1970s heroin use was disproportionately concentrated among young urban males whose first opioid of abuse tended to be heroin. However, by the 2000s heroin users were more likely to be white men and women living in less urban areas who were introduced to opioids through prescription drugs. The shift of opioid abuse to less urbanized areas of the United States was in part driven by differences in opioid prescribing rates. Garcia et al. (2019) find that patients in the most rural counties had an 87 percent higher chance of receiving an opioid prescription compared with patients in large central metropolitan counties during their 2010s study period. Since higher opioid prescribing rates tended to put those patients at higher risk for addiction and overdoses, higher rates of opioid-related deaths were reported in rural areas during the early 2010s. Figure 1 displays fatal overdose trends in urban vs. rural counties from 1999 through 2021.[1] Rural overdose death rates increased and steadily converged with urban rates over the 2000s before surpassing them slightly from 2009 through 2012. However, after 2015 per capita overdose deaths in urban counties increased and diverged considerably over their rural counterparts.

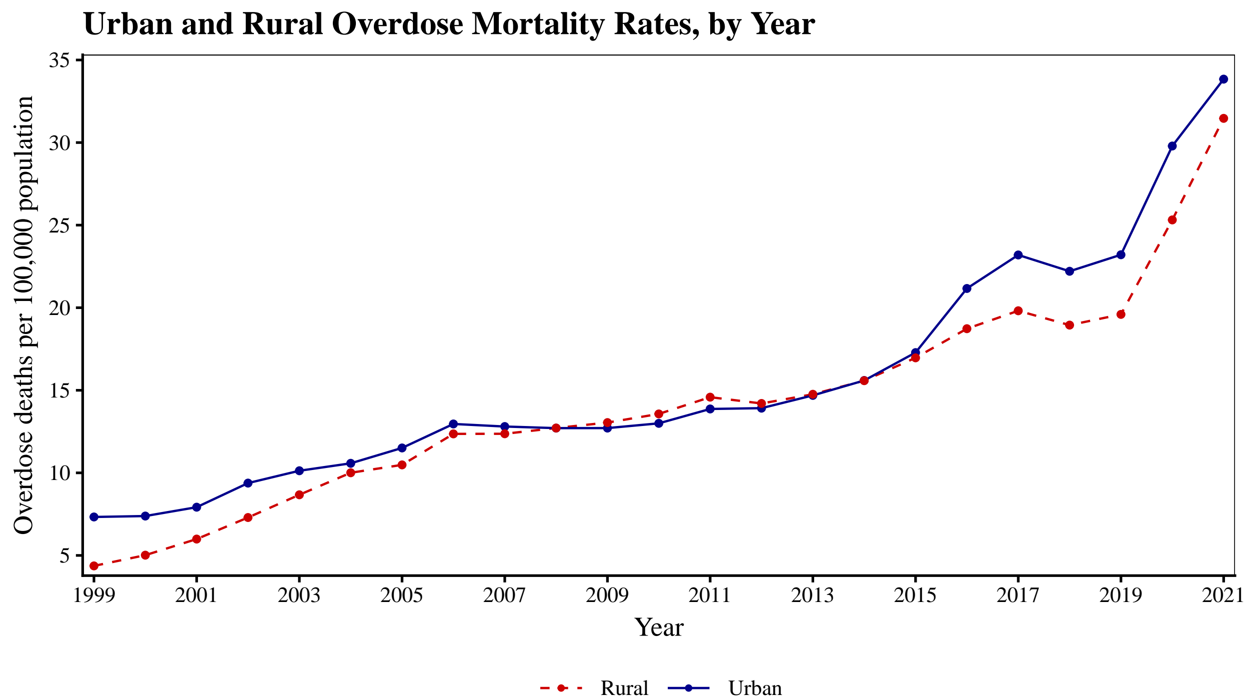



Figure 1: Drug overdose deaths by urban–rural status: United States, 1999-2021. Overdose deaths per 100,000 population. Urban, rural determined by 2013 CDC Urbanization Codes. Source: CDC WONDER Multiple Cause of Death

[1] Population estimates in many counties post-2021 are missing so these data are excluded.

## 2.2 The Second Wave (Heroin)

Policy measures to combat the overprescribing of opioid medications (e.g., prescription drug monitoring programs, pain clinic laws, prescription duration limits) in the mid-2010s resulted in the halving of opioid prescribing nationally from 2012 to 2017 (Owens, 2019). Legal pressure applied to pharmaceutical companies spurred reductions in prescribing rates, less aggressive marketing, and the introduction of an "abuse-deterrent" reformulation of the most popularly abused pill. However, this simultaneously pushed opioid users to use more abundant and cheaper illicit narcotics such as heroin and eventually fentanyl (Alpert et al. 2018).

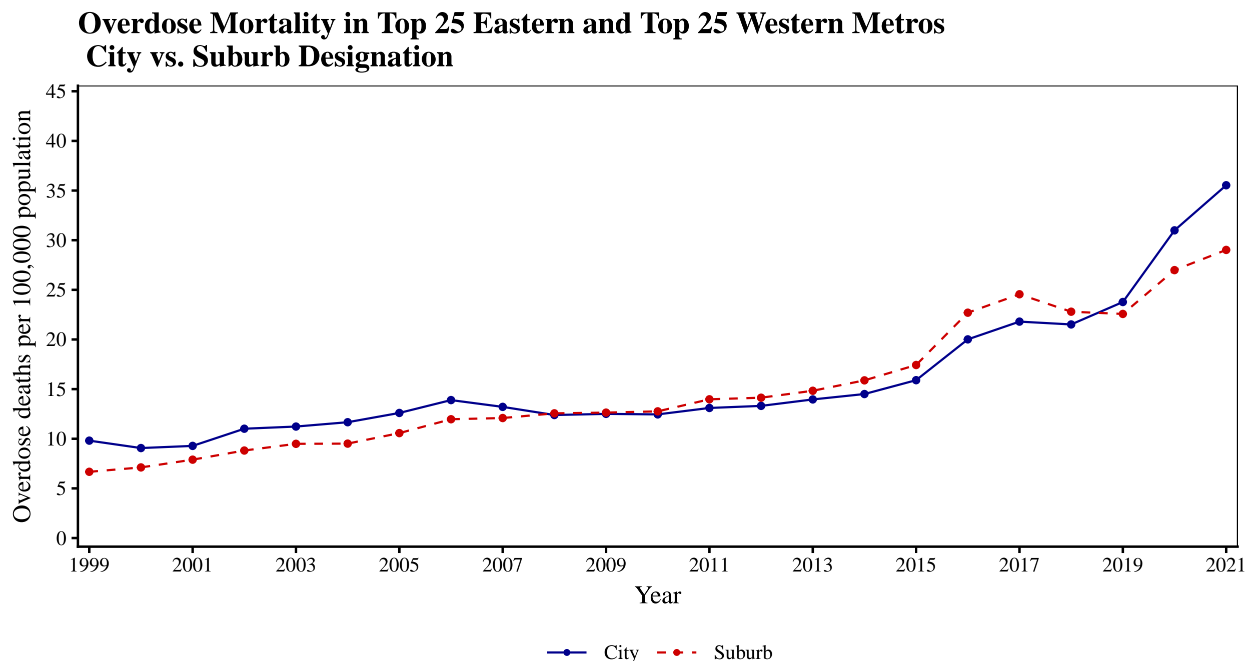
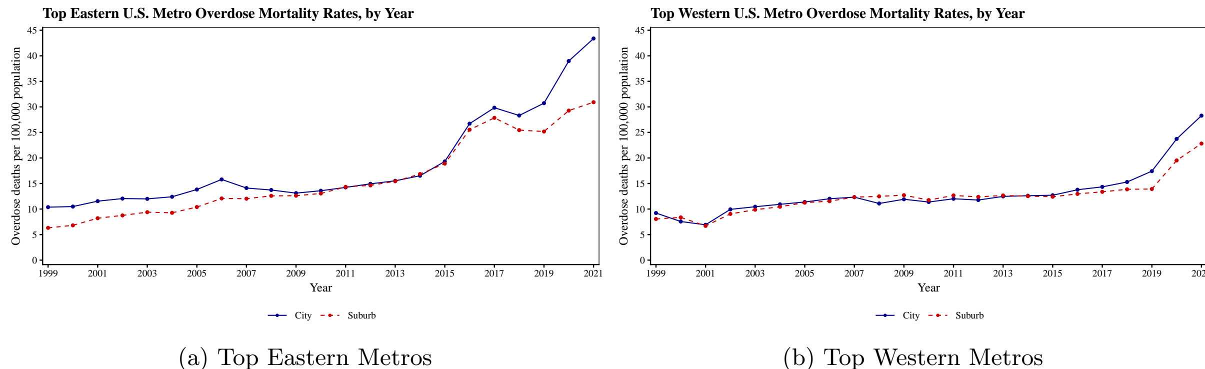



Figure 2: Overdose mortality per 100,000 residents in Top 50 U.S. Metro Areas

*Notes:* Data from CDC WONDER Multiple Cause of Death files 1999-2021. Values are counts of all deaths flagged as drug/alcohol induced or caused. Counties within top 25 metro areas are grouped by CBSA and categorized as city or suburb based on 2013 urbanization classification. A city county may include neighboring municipalities not in the core city boundaries but is intended to represent the urban core of a CBSA.

Figure 2 decomposes the most highly populated U.S. metropolitan areas into their urban core county versus their suburban counties, all of which would be counted as urban in Figure 1. Figure 2 shows that suburban counties became increasingly impacted by overdose deaths through the first wave of the opioid epidemic, and the abundance of heroin made the overdose epidemic a more suburban than urban phenomenon within major metro areas by the early 2010's. For the first time, the deadly impacts of narcotics abuse were worse in the suburbs than the inner city.




(a) Top Eastern Metros

(b) Top Western Metros

Figure 3: Overdose deaths per 100,000 population in Top Eastern and Western Metro Areas.

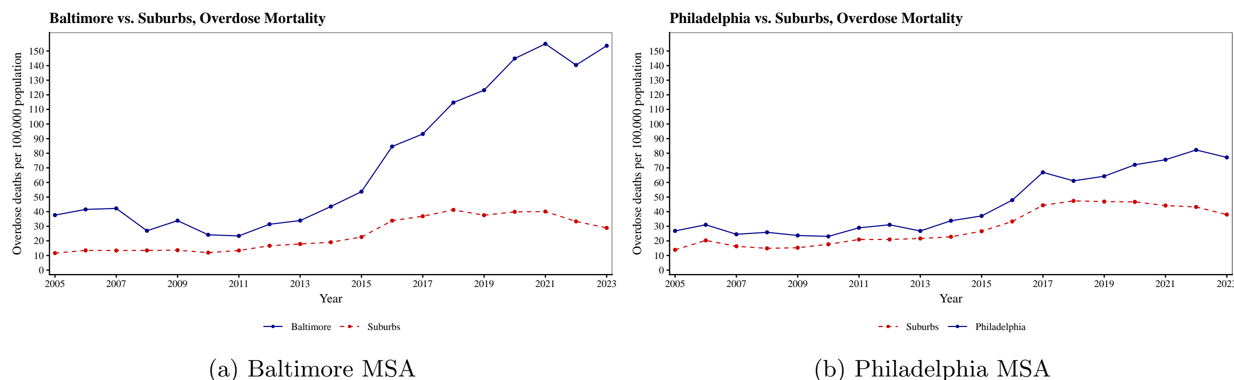
*Notes:* Each panel shows overdose mortality per 100,000 residents. Data from CDC WONDER Multiple Cause of Death files 1999-2021. Values are counts of all deaths flagged as drug/alcohol induced or caused. Panel (a) is limited to top 25 U.S. metros by population east of the Mississippi River. Counties within top 25 metro areas are grouped by CBSA and categorized as city or suburb based on 2013 urbanization classification. A city county may include neighboring municipalities not in the core city boundaries but is intended to represent the urban core of a CBSA. Panel (b) is top 25 U.S. metros by population east of the Mississippi River.

## 2.3 The Third Wave (Fentanyl)

The trend towards increasing suburbanization reversed course drastically with the arrival of fentanyl, a synthetic painkiller roughly 50-100 times stronger than morphine. When suppliers introduced fentanyl into the heroin supply of east coast drug markets in the mid- to late-2010s , the number of opioid deaths from fentanyl soared (Ciccarone, 2017b; Donahoe & Soliman, 2025). Fentanyl deaths outpaced those from both prescription opioids and heroin by 2016 and tripled by 2022 when 74,000 Americans died from fentanyl (compared to 15,000 prescription opioid and 6,000 heroin deaths that same year) (Saunders et al., 2026). Donahoe & Soliman (2025) discuss the differential introduction of fentanyl between coasts and some of the structural factors impacting its diffusion. In short, fentanyl began to appear as an adulterant in east coast powder heroin around 2013 and became ubiquitous by 2016. Its introduction on the west coast came later in the 2010s. Since heroin distributed west of the Mississippi River was predominantly tar based (Donahoe & Soliman 2025), fentanyl was introduced in illicit markets as a separate product rather than as an adulterant to heroin. Figure 3 demonstrates that once fentanyl became entrenched in the illicit opiate supply, overdose mortality concentrated in the urban cores of major metropolitan area.

Still, the coarse distinction between core and suburban counties above masks important heterogeneity. For most major cities, the core city of a metro exists in a county alongside other suburban municipalities (e.g. Cook County, IL, Los Angeles County, CA). To illustrate the degree of divergence between urban core and suburbs, Figure 4 zooms in on two eastern US cities that exist as their own county- allowing for a visual that truly separates city from suburb. In Baltimore and Philadelphia, overdose mortality rates were already higher than in their suburbs over the first and second waves of the opioid epidemic (both of which are notorious for their urban heroin markets). However, the urban core overdose mortality rates of both cities diverged even further from their respective suburbs after the fentanyl wave. By 2023, the urban

core overdose mortality rates were roughly double their respective suburban rates in Philadelphia, while the urban overdose rate in the city of Baltimore grew to be more than five times its suburban rate.



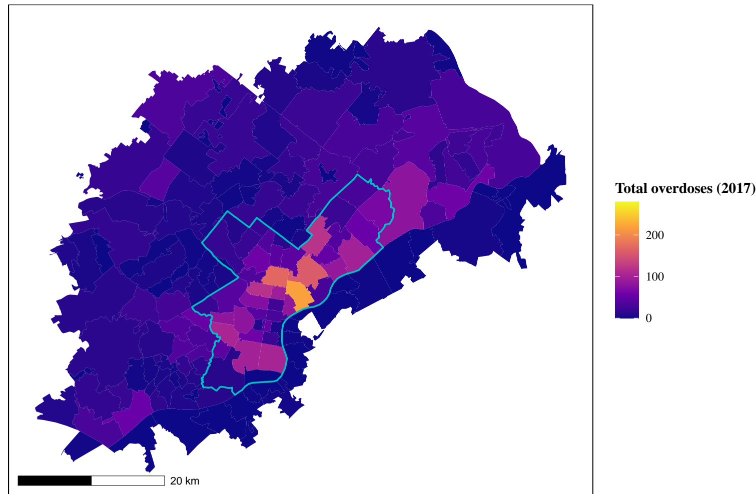

(a) Baltimore MSA

(b) Philadelphia MSA

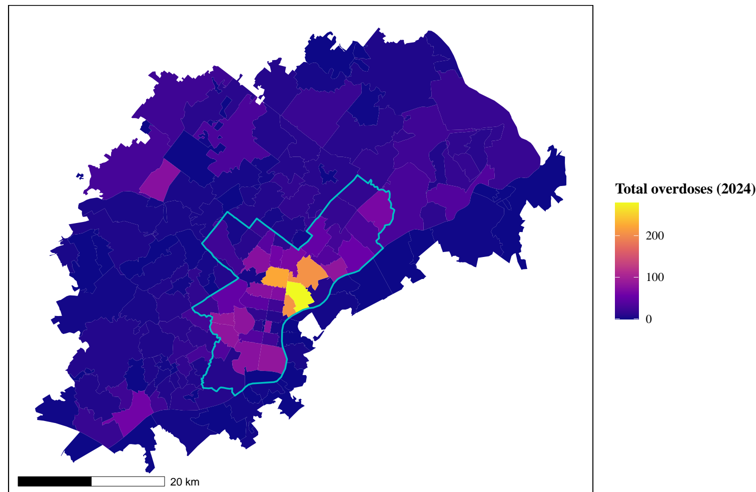
Figure 4: Overdose deaths per 100,000 population in the Baltimore and Philadelphia Metro Areas.

*Notes:* Each panel shows overdose mortality per 100,000 residents. Data from CDC WONDER Multiple Cause of Death files 1999-2021. Values are counts of all deaths flagged as drugalcohol induced or caused. Cities were selected since core counties are coterminous with city borders.

Finally, we zoom in even further on Philadelphia to observe the increasing urbanization of overdose deaths after the fentanyl wave of the opioid epidemic. Drawing on proprietary inpatient discharge data from the Commonwealth of Pennsylvania we can observe hospital admissions for for primary and secondary diagnosis codes that are consistent with drug overdoses to examine the geography of overdose occurrence (not necessarily mortality) across the city and suburbs with a high degree of spatial granularity. Figure 4, below, maps the zip codes of Philadelphia and its inner ring suburbs at both the start of fentanyl's spread in 2017 compared to 2024. In 2017, overdose mortality rates between city and suburb in Philadelphia had not yet dramatically diverged as we can see in Figure 4c. When we look at zip code level impacts in Figure 5a, we can see that the drug overdoses were somewhat diffused across the city and nearby suburbs. It is clear that there was already a particularly pronounced overdose hot spot in the lower northeast of the city that encompasses the neighborhood of Kensington, which houses a well-known and longstanding open-air drug market (Scavette 2019; Porreca 2026). However, in 2017 there were also notable hot spots in neighborhoods through the northern and southern parts of the city, as well as in Bucks County suburbs to the northeast.




(a) 2017




(b) 2024

Figure 5: Total overdoses by zip code (Philadelphia, PA)

*Notes:* Each panel shows total overdoses admissions by zip code. Data are from Pennsylvania Inpatient Discharge Data File. Overdoses are identified by ICD diagnostic codes T40, T424, T427, T436, and T465. The Philadelphia city boundary is outlined in blue. Periphery are all zip codes within a 20-kilometer radius of city. Across panels, overdoses shift towards the urban core, with the most pronounced concentration in Philadelphia's Kensington neighborhood. ZIP codes 19134 and 19125, which constitute the core of Kensington, recorded 218 and 83 overdoses in 2017, respectively. By 2024, these figures rose to 279 in 19134 and 207 in 19125. In 2024, ZIP code 19125 had the highest overdose rate in the city, at 210 overdoses per 100,000 residents.

By 2024, around a decade after fentanyl's first appearance in the illegal opioid supply, the geography of overdoses across Philadelphia had changed drastically. Panel B of Figure 4 shows fewer overdoses nearly everywhere across the city. The exception is in the same pre-existing urban core neighborhoods that stood out as hot-spots in 2017. Now, however, the smaller hot spots throughout the city had dissipated while overdoses grew even more concentrated in the Kensington area. Fentanyl's spatial impact essentially shrank

inwards to a few small cores in the city center.[2]

Fentanyl has shifted the geography of the opioid epidemic. Whereas heroin drove the phenomenon towards a high degree of spatial disaggregation, fentanyl's arrival has precipitated an especially pronounced concentration within the urban core. Zooming in on one city, for which data was available, we can see even further that *within* the urban core overdose mortality has grown even more concentrated, with a shift towards a small set of pre-existing hot spots.

# 3 Potential Mechanisms

The increasing spatial concentration of overdoses that has followed fentanyl's proliferation is the result of the interplay of both supply and demand side dynamics. First, on the supply side fentanyl's lower weight-to-value favors a physical concentration of distribution relative to the dispersion common in heroin markets. Second, the heightened severity of fentanyl withdrawal, relative to that of heroin, pushes users to source and consume more urgently. This leads to consumption occurring more regularly and in greater proximity to the site of purchase. Together these two trends change the geography of consumption (and by effect overdoses (Hall et al. 2021)), concentrating a formerly more dispersed phenomenon into a smaller subset of urban areas in which the drug is both purchased and consumed.

## 3.1 Supply Side: Retail Agglomeration

Reductions in transportation costs drive spatial agglomeration. Famously, Glaeser & Kohlase (2004) discuss this trend at a "macro" level across the US as transportation costs declined nationwide during the 20th century. The shift from heroin to fentanyl in illicit opioid markets has had a similar effect and has likewise driven down transportation costs. This in turn has led to a greater degree of spatial concentration at the retail-level. Insights into the impact of transportation costs for any good on its downstream price can be gleaned from examination of that good's weight-to-value ratio (Hummels 2007). A lower weight-to-value ratio implies a lower transportation cost, holding all else constant.

Comparisons between the weight-to-value ratios of heroin and fentanyl need to take into account the relative potencies of each substance. Fentanyl may be as much as 50 times as potent as heroin at equivalent weights (U.S. Government Accountability Office, 2025). Despite this, the low cost of pure fentanyl has driven down production costs, in turn spurring a reduction in relative "dosage" costs throughout the supply chain (Caulkins 2024). Pardo et al.(2019) estimate that a single morphine equivalent dose of fentanyl is 99% cheaper to produce than of that of heroin. Smaller volumes of fentanyl yield more morphine equivalent doses at lower costs, while the physical quantities of narcotics consumed remained constant (Creppage et al. 2018; Mars et al. 2018). The significantly lower weight-to-value ratio of fentanyl relative to heroin translates to much lower transit costs for traffickers.

[2] It is also notable that by 2024 two farther-flung suburban areas have begun to emerge as hot spots in their own right. These are Chester and Norristown: the two Pennsylvania areas discussed in Porreca (2026) as "satellite" drug markets to the larger Kensington market in the urban core.

The trade costs of a good are composed of transportation costs and the costs imposed by various hazards and liabilities, along with those imposed by other factors necessary to bring the goods from the point of production to the retail level consumer (Anderson & Wincoop 2004). Mechanically, a reduction in transportation costs while holding other costs constant increases the relative share of those other costs in contributing towards the overall trade cost. Reuter & Kleiman (1986) argue that the principal trade cost in the markets for illegal narcotics is risk management. Pollack & Reuter (2014) state that excessive risk exists in illegal drug market, arising from law enforcement actions, predation, and violence within the market. As such, a reduction in transportation costs in this setting increases the relative importance of those risks towards the overall cost faced by market operators. Measures to mitigate the risk from predation and enforcement become increasingly important as the market shifts from higher weight-to-value heroin towards fentanyl.

It is a core logic of classic industrial organization that markets with higher transportation costs favor decentralization (Beckenstein 1975). A prime example of this is the market for concrete, which due to its high transportation costs exists largely as quasi-independent markets geographically (Syverson 2004). This decentralization emerges in high transport cost industries as a result of the tradeoff between variable transport costs to serve demand and the fixed costs of opening and operating additional locations. In high transport cost industries these variable costs dominate, pushing suppliers to operate a broader network of locations to minimize these costs. This logic is inherent to all markets. However, in the markets for illegal narcotics security and risk management costs come to dominate as transportation costs decline.

Risk management costs in the retail-level markets for narcotics are largely fixed overhead. They are not, for the most part, proportional with the quantity sold. Levitt & Venkatesh (2000) document more-or-less fixed staffing requirements for drug gangs operating a street corner, with each gang employing a single lookout. Leong et al. (2022) likewise document the existence of fixed costs related to wages and storage that do not vary with the quantity sold. This principle is modeled directly in Kleiman (1993), in which the marginal security costs of illegal drug markets with respect to quantity are modeled as being strictly concave. Given that these costs are largely fixed overhead, it is optimal for suppliers in the markets for illicit narcotics to operate fewer locations. This tendency comes to dominate even further as the shift from heroin to fentanyl induces a decline in transport costs, making risk management the relevant cost margin to suppliers.

The increasing importance of risk management costs and the decrease in transportation costs together push towards an increasing spatial concentration of retail-level narcotics sales. This does not necessarily entail that there is a decline in the number of sellers operating in the market. Rather, as in the agglomeration economies discussed in Glaeser & Kohlhase (2004), sellers locate in closer proximity to one another in areas in which the fixed costs of operation (such as risk management in the present case) are lesser. Further, industries that add weight in the production process, such as the illegal narcotics industry in which weight-gaining adulterants are added throughout the distribution chain, have an incentive to locate production near the point of consumption (Holmes & Stevens 2004). This pushes even more towards an agglomeration in

which sellers and consumers spatially co-locate. Fentanyl's higher potency allows for the addition of more adulterants than lower potency heroin, further increasing the economic incentive for sellers to concentrate themselves around existing user hubs. Fentanyl's high potency and lower cost accelerated a tendency towards spatial concentration as it supplanted heroin in the markets for illegal narcotics.

### 3.2 Demand Side: Consumption Near the Point of Sale

The shift from heroin to fentanyl also changed the way individual drug users deal with their addictions. The onset of withdrawal symptoms begins within just a few hours of use, substantially faster than the waning of the effects of heroin, which could last for up to twelve hours (Ciccarone et al. 2017). The withdrawal from fentanyl can be much more severe and unpredictable than that from heroin or other opioids (Englander et al. 2024; Sharma et al 2024). Because of the enhanced risks associated with fentanyl withdrawal, current guidelines for burprenorphine induction as a treatment for opioid use disorder recommend induction beginning not less than 24 to 48 hours after last use compared to the 6 to 12 hours recommended for heroin (Cunningham et al. 2020, Varshneya et al. 2022). In sum, the increased severity of fentanyl withdrawal relative to that of heroin, coupled with the more rapid dissipation of the drug's intended effects, creates a more desperate situation among drug users in which they much urgently seek to source and consume the drug regularly (Kral et al. 2025).

Fentanyl's enhanced withdrawal risk has created a situation in which narcotics are consumed in riskier settings and more quickly upon purchase. Interviews conducted by Frank et al. (2023) record users stating that the urgency with which withdrawal sets in necessitates rapid consumption, preempting safer harm reduction behaviors. Thus, it is unsurprising that in the era of fentanyl Bates et al. (2018) and Ratcliffe & Wight (2022) record a preference among users for consumption near the locations of drug markets. Karanidos (2019), an ethnography of Philadelphia's narcotics market, records users injecting immediately upon leaving the site of purchase with "more patient" users walking one or two blocks before ingesting.

## 4 Policy Implications

Each wave of the opioid epidemic has reshaped the geography and demography of overdose risk. Our findings suggest that the fentanyl wave has done so by increasing spatial concentration. Users and dealers increasingly co-locate, clustering retail-level trafficking, consumption, and overdoses geographically. We observe this pattern both across metropolitan areas and within cities, depending on the level of spatial aggregation examined. Within metros, overdose mortality shifts from suburban peripheries toward the urban core. Within Philadelphia, overdose-related hospital admissions become increasingly concentrated in a relatively small set of inner-city neighborhoods. Fewer areas now persist as hotspots, but those that do bear a growing share of the region's overdose burden.

This growing degree of spatial concentration creates a clearer opportunity for targeted intervention. On the enforcement side, recent work suggests that well-targeted efforts to disrupt urban drug markets

can generate meaningful downstream regional effects (Porreca 2026). From a harm reduction perspective, greater concentration may also permit more efficient deployment of naloxone, outreach, and emergency response capacity by focusing scarce resources on the places where overdose risk is now most acute.

At the same time, policymakers and practitioners should anticipate further geographic change. Potency-enhancing tranquilizers have begun to become increasingly common in retail-level street opioid markets (Montero et al. 2022), but it remains unclear how their spread will affect the spatial concentration of drug consumption and overdose. That uncertainty makes the present moment especially important. The concentration patterns associated with the fentanyl wave may create a temporary window in which harm reduction practitioners and first responders can more effectively target life-saving resources before the growing prevalence of tranquilizers alters both the clinical profile and the geography of overdose risk, particularly through the respiratory depression and related complications associated with these overdoses (Owusu-Antwie et al. 2025). Each successive wave reshapes the geography of overdose risk; effective responses will depend on the ability of policymakers and practitioners to track, anticipate, and act on these shifting spatial patterns.

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