Economic Conditions and Opioid Mortality

by

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Abstract

This paper examines the relationship between economic conditions and opioid mortality. Specifically, I analyze how changes in the unemployment rates are related to fluctuations in opioid overdose deaths, using U.S. mortality data over an extended study period from 1999 to 2023 to capture a more comprehensive evolution of the relationship. At the state level, a one-percentage-point increase in the unemployment rate is associated with a decrease of 0.53 deaths per 100,000 from any opioid-related death. The estimated reduction is slightly larger (0.58) for heroin and synthetic opioid-related deaths. When restricting the analysis to different sample periods and focusing on major shocks, including the COVID-19 pandemic and periods of heightened import competition, the pattern either reverses or weakens. This suggests temporal instability in the relationship and indicates the limitations of earlier studies that relied on shorter time frames.

Keywords: economic conditions, opioid mortality, COVID-19, import competition

Contents

1 Introduction

Opioid overdose deaths are one of the most pressing health challenges in the United States. In the past two decades, there has been a ninefold increase in opioid-related overdose deaths. The link between economic well-being and physical health outcomes is well established (Deaton, 2002). Previous findings have examined how the economic environment, such as employment conditions, influence opioid mortality (Gerdtham & Ruhm, 2006; Hollingsworth, Ruhm, & Simon, 2017; Carpenter, McClellan, & Rees, 2017; Ruhm, 2019; Brown & Wehby, 2019), and the authors mostly find that economic downturns adversely impact health. However, opioid deaths in the U.S. have been increasing continuously, even during times of economic recovery. Nevertheless, these conclusions do not sufficiently explain the rise in opioid deaths in more recent years. This paper aims to examine how opioid mortality varies with economic conditions over a 25-year period from 1999-2023. Using the unemployment rate as the indicator of economic cycles, I explore whether opioid mortality worsens or declines during downturns or upturns at the U.S. state level. I also focus on two periods with major trade and pandemic shocks to further investigate the dynamic changes of this crisis.

The opioid crisis in the U.S. evolved in three waves during 1999-2023 with different types of opioids driving the mortality (Centers for Disease Control and Prevention, 2024b). The first wave occurred in the mid-1990s with prescription opioids being the main driver of opioid deaths due to over-prescription and marketing to healthcare providers and consumers without sufficiently informing the public of opioids' addictive nature (Maclean, Mallatt, Ruhm, & Simon, 2021). The second wave began in 2010 when heroin overdose deaths started to increase substantially. From 2013 onwards, there was a sharp increase in synthetic opioid overdose deaths, mostly involving fentanyl. Synthetic opioids became the leading fatal opioid during this period (Figure 2).

During the same period, three major economic downturns are documented: the early 2000s recession, the 2007-2009 Great Recession, and the brief contraction following the 2020 COVID-19 pandemic (National Bureau of Economic Research, 2023). Each downturn led to widespread unemployment and increased economic distress, especially for individuals who were financially and physically vulnerable. Prior research focusing on the pre-2015 period has identified unemployment as a risk factor for opioid overdose, after accounting for contextual and demographic differences (Hollingsworth et al., 2017).

Opioid mortality has therefore been found to be countercyclical to macroeconomic conditions. That is, opioid deaths increase as the economy deteriorates, and this is usually reflected by an increase in the unemployment rate. However, as the economy continues to change dynamically, it remains unclear whether this cyclicality has persisted in more recent years.

This paper examines the relationship between short-run local economic conditions and opioid mortality, extending the analysis to a longer period (1999–2023) than previous studies to obtain a more comprehensive view of this connection. The first objective is to estimate the overall cyclical pattern of opioid mortality leveraging 25 years of U.S. state-level panel data. This estimates the overall relationship between unemployment and opioid overdose deaths. Given the limited evidence on how this relationship has evolved in more recent economic downturns, this paper further investigates whether the COVID-19 pandemic period has modified the connection between unemployment and opioid mortality. Specifically, I examine whether states experiencing more severe COVID-19 infection rates see different patterns or magnitude in the unemployment-opioid mortality relationship. In addition to major economic downturns, persistent structural economic changes could implicitly influence regional employment and in turn impact mortality (Pierce & Schott, 2020). To address such impact, I incorporate variation in state exposure to Chinese imports during 2000-2007 to assess how trade shocks interact with unemployment in influencing opioid mortality. While the paper faces data limitations and challenges to account for possible confounders, robustness checks are included to strengthen the validity of the findings.

The main finding is that as the unemployment rate increases, opioid deaths are predicted to decrease, indicating a procylical pattern. This relationship holds for both any opioid-related deaths and deaths involving illicit opioids, such as heroin and some synthetic opioids. The pattern stays consistent when using alternative economic condition proxies, including labour force participation rate and employment-to population ratio. The association is generally consistent over time. A brief reversal appears around 2014 and 2015, when the relationship turns positive but is statistically insignificant. The relationship also reversed during the COVID-19 period; however, there is no evidence that state COVID-19 severity amplifies the relationship. When examining variation in state import exposure, the negative association between unemployment and opioid deaths is attenuated, though the direction of the relationship remains the same. The findings question the prevailing view that opioid mortality increases during economic downturns. Further, I find that the relationship becomes increasingly unstable and shifts during times of economic downturn influenced by distinct external shocks.

2 Literature Review

Findings over the past two decades reveal a counterintuitive pattern of how economic conditions shape health outcomes, that is, mortality declines during economic downturns (Gerdtham & Ruhm, 2006; Ruhm, 2015; Hollingsworth et al., 2017). This pattern is perplexing in that higher income improves health outcomes at the individual level (Chetty et al., 2016; Deaton, 2002; Case, Lubotsky, & Paxson, 2002). However, when economic conditions are measured at aggregated levels, mortality tends to decline when economic conditions worsen. This has sparked interest in whether the same pattern holds for specific causes of deaths, including opioid-related mortality. Despite the difficulties in identifying drug deaths, a few empirical studies have analyzed the impact of economic conditions on drug and opioid mortality.

Most studies find a countercyclical pattern for opioid mortality, meaning when the economy deteriorates, which is often measured by an increase in unemployment rate, opioid overdose deaths rise. Leveraging U.S. county-level panel data of the period 1999-2014, Hollingsworth et al. (2017) find that as the unemployment rate increases by one percentage point, the opioid death rate per 100,000 increases by 0.19(3.6%). Their study extends to the overall drug death rate which also follows a countercyclical pattern, driven primarily by opioid deaths. Additionally, the association is stronger among the White population. Using more economic condition proxies including poverty rate, median household income, and median income, Ruhm (2019) finds positive relationships, particularly when using median income. Similarly, Brown and Wehby (2019) find an identical positive association between the unemployment rate and the opioid overdose death rate at the U.S. state level.

Although a positive relationship is identified, there are no unanimous findings on the magnitude of the relationship. Rather, researchers find the relationship sensitive to different measurements. State-level data provide larger estimates around 0.24 compared to 0.19 (Hollingsworth et al., 2017; Brown & Wehby, 2019). Bartik (1996) and Hoynes (2000) notes that economic indicators for smaller geographic units are more subject to measurement errors as more survey data is used during data collection. The smaller county-level estimates also reflect the fact that macroeconomic effects are understated at the county level (Lindo, 2015). When including multiple economic proxies simultaneously, statistical insignificance emerges, and the relationship between opioid deaths and some proxies reverse due to high collinearity (Ruhm, 2019; Brown & Wehby, 2019).

Beyond combined opioids mortality, illicit opioid deaths have been analyzed separately as the mechanism through which economic conditions impact illicit drug-involved mortality can be systematically different. However, due to data limitations, few studies focus on illicit opioid mortality. Using heroin and synthetic opioids as proxies, Ruhm (2019) finds a stronger positive relationship between the illicit opioid deaths rate and the unemployment rate than its prescription counterpart. While not focused on mortality, Carpenter et al. (2017) report mixed cyclical patterns of illicit drug use but provide strong evidence that economic downturns are positively associated with prescription pain reliever use and clinical substance use disorder involving opioids during 2002 and 2015. Carpenter et al. (2017) suggest that the cyclicality of substance use disorders differs depending on the addictiveness of a particular drug. Highly addictive drugs can lead to persistent disorder even after economic conditions improve. They find tentative evidence of symmetric effects —substance use disorders increase and decrease similarly during economic upturns and downturns. In general, the countercyclical pattern is found for illicit opioid overdose and mortality.

Some studies take a behavioral perspective to examine how economic conditions influence drug use, offering insights into the individual-level mechanism underlying the cyclical nature. Rather than a direct association between unemployment and opioid mortality rates, Yang, Kim, and Matthews (2023) provide evidence that unemployment reduces social capital, that is, it reduces the connection and trust between individuals, and this reduction indirectly contributes to more opioid misuse and deaths due to isolation and hopelessness. Unemployment can also contribute to opioid mortality through other adverse health behaviours, such as smoking. Yang et al. (2023) find that unemployment increases social isolation and smoking prevalence, which is positively related to opioid mortality. Medically, there is substantial co-occurrence between tobacco smoking and opioid misuse (Zale et al., 2014; Parker & Weinberger, 2020; Rajabi, Dehghani, Shojaei, Farjam, & Motevalian, 2019). Rajabi et al. (2019) report that current smokers have over

8 times the odds of developing opioid use disorder than non-smokers. Although the causal link between smoking and opioid misuse or mortality is yet to be validated. This evidence suggests that the connection between unemployment and opioid mortality is more than one-dimensional.

An extensively documented theory, called "deaths of despair," provides an explanation on how economic distress arises during economic downturns and contributes to increased risk of drug overdose. Introduced by Case and Deaton, economic stressors like unemployment, deindustrialization, and stagnant wages bring desperation that can lead people to risky uses of substances to alleviate stress. Deaths due to drug overdose, alcohol, and suicide are particularly evident among the middle-aged, less-educated white population (Case & Deaton, 2015). Psychological distress or social exclusion can lead to increased use of illegal drugs to cope with stress (Nagelhout et al., 2017). Such a mechanism is commonly employed to explain the countercyclical pattern of drug overdose.

However, Ruhm (2019) disagrees with deaths of despair being a driver of deaths. Using county-level evidence, Ruhm (2019) states that less than one-tenth of the rise in drug and opioid-related death is explained by economic indicators. Economic conditions are not the primary driver of the opioid crisis but rather the changes in drug supply, particularly the transition from prescription opioids to illicit opioids. Ruhm (2019) also states that restricting prescription opioids does not always reduce overdose deaths; instead, the impact depends on whether an area has an existing illicit opioid market. Overall, the drug environment or drug supply plays a more important role in opioid deaths than local economies. "Deaths of despair," if it has any influence, is rather a side factor.

Some studies approach the cyclicality by analyzing drug supply side changes during economic cycles. The drug market supply is typically composed of prescription drugs and illicit drugs. During an economic downturn, the illicit drug market can respond by shifting its production. For example, the production of marijuana and methamphetamine becomes the preferred options during a recession (Carpenter et al., 2017). If the production transitions to more addictive drugs, the risk of overdose deaths can increase. Policy changes during downturns, such as budget shortfalls, could impair the effectiveness of drug law enforcement (Carpenter et al., 2017), indirectly leading to more supply. Prescription opioids supply is not independent of individual economic status. The increase in the prescription opioid supply is associated with higher drug overdose mortality and lower socio-economic status (Fink et al., 2023). According to Fink et al. (2023), drug overdose deaths are more concentrated in counties with greater prescription opioid supply and greater economic distress, and there is an interplay between prescription and illicit opioids. Among all types of opioids, heroin is more responsive to changes in prescription opioid supply. When prescription opioid supply decreases, heroin overdose deaths increase. This is more evident in counties that are relatively well-off and have better income equality.

There is little evidence that supports procyclical patterns. Some demand-side theories take the position that economic decline reduces illicit drug use. Nagelhout et al. (2017) identify two mechanisms that are procyclical. The income mechanism suggests that reduced income during downturns leads to lower spending on illicit drugs, either through decreased use or substitution of cheaper alternatives. The job chances mechanism suggests that people may reduce illegal drug use to be able to keep a job. However, the authors do not find sufficient empirical evidence to support such mechanisms.

Hollingsworth et al. (2017) find a notable exception by race. In county-level models, unemployment is negatively correlated with opioid death rate for Black Americans. The authors suggest this anomaly could reflect data issues or sensitivity of estimates. This hints that economic downturns may not affect all groups uniformly. Rudolph et al. (2020) discover similar pattern for Black and Hispanic Americans. For them, higher rates of labour force non-participation are associated with lower overdose mortality in the short-run. This inverse relationship persists for Black Americans over a 15-year period, highlighting the heterogeneity in how the economic landscape impacts overdose risks. Wu and Evangelist (2022) find that the adverse effect of job loss on opioid mortality declines with increasing state unemployment insurance benefit levels. In other words, income support can disrupt the link between economic decline and opioid deaths by reducing financial stress, reducing the chance of individuals having despair-driven substance abuse. An economic downturn in a state with strong safety nets might coincide with lower opioid mortality.

The current literature leaves a few gaps. First, almost all studies investigating the relationship between macroeconomic conditions and opioid mortality were conducted during the period of 1999-2015, leaving a gap for evidence during the post-2015 periods.

Major short-term unemployment occurred during the COVID-19 pandemic in 2020-2021. Sprague, Yeh, Lan, Vieson, and McCorkle (2022) have examined overdose deaths during the COVID-19 years but with a focus on the impact of economic payments instead of economic conditions. There remains little evidence on whether the cyclicality of opioid overdose deaths has shifted in more recent years.

Second, the definition for opioid death is not uniform across studies, which can lead to measurement inconsistency. Most research identifies opioid deaths using the causes of death information from the mortality data, which records several types of opioids. When Hollingsworth et al. (2017) define opioid deaths, they exclude heroin for the reason that the heroin death rate was low during the sample period of 1999-2014. They also perform probit imputations on the death counts to address undercounting issues. However, this could potentially bias the actual death counts and generalize opioid death definition. This also limits comparability across studies, as other studies include heroin-involved deaths (Ruhm, 2019). Alternatively, survey data has been used to examine cyclicality in opioid use but can be exposed to respondent subjectivity in identifying drug use frequencies and categories (Carpenter et al., 2017). For clarity, this paper includes a more comprehensive definition of overall opioid deaths and sub-categories.

Although it is difficult to account for all contributing factors, most studies focus on the contemporaneous relationship between economic downturns and opioid mortality. However, the impact of economic conditions is unlikely to be immediate. Individuals could gradually lose income, access to healthcare, or shift to more dangerous substances over time. Few studies examine the lagged impact of unemployment. This study does not directly model lagged unemployment impacts, and this limitation highlights the need for considerations in future research that better capture the long-term effects of economic conditions on opioid overdose mortality.

3 Data

3.1 Opioid Mortality

The state-level opioid mortality data are extracted from the Centers for Disease Control and Prevention (CDC) CDC Wonder portal for the period of 1999-2023 for 50 U.S. states and the District of Columbia.

CDC Wonder is a public access data query portal that provides aggregated mortality data at the state level. The portal identifies specific causes of death using the International Classification of Diseases, Tenth Revision (ICD-10) codes. A death certificates is the source for the mortality data reported by CDC. In each U.S. death certificate, both underlying cause of death and multiple causes of death are indicated and then coded in the database based on the ICD-10 standard. Previous studies have defined opioid deaths using the ICD-10 codes X40–X44, X60–X64, X85, Y10–Y14, or Y35.2 for the underlying cause of death (Hollingsworth et al., 2017). These codes indicate drug poisoning deaths except for Y35.2, which is defined as deaths due to "legal intervention involving gas" (Centers for Disease Control and Prevention, 2024a). To only include drug-induced death records in this paper, Y35.2 is excluded in the sample. To further identify opioid-related deaths, codes T40.0-T40.4, and T40.6 are used for the multiple causes of death (Centers for Disease Control and Prevention, 2022). T40.0 is the code used for Opium. T40.1 indicates drug poisoning deaths involving heroin. T40.2 involves natural and semi-synthetic opioids. T40.3 is used for Methadone, and T40.4 is for other synthetic narcotics. In the case of unspecified narcotics, T40.6 is used when an opioid is reported without more specific information (Centers for Disease Control and Prevention, 2025). Since a single death can involve more than one type of opioid, each code does not uniquely identify a specific type of opioid-related death but rather indicates the involvement of opioids. In this paper, deaths involving any opioids are defined using codes T40.0-T40.4, and T40.6. Codes T40.1 and T40.4 are used to identify deaths involving heroin- and synthetic opioids-related deaths as a proxy for illicit opioids-related deaths.

Due to privacy protection, aggregated data from CDC Wonder is subject to censoring policies. Death counts ranging from 1 to 9 are suppressed. As a result, approximately 1% of the any opioid-related deaths observations over the full sample period are suppressed, and the proportion increases to 10% for heroin and synthetic opioids-related deaths.

Suppressed observations are imputed with a value of 5, the average of the suppression interval. For the sample period 1999-2023, death counts are final and are not subject to reporting delays and updates.

CDC also provides individual-level mortality data files on the Vital Statistics Online Data Portal, which includes more detailed information on causes of death, demographics, education level and employment status. However, the public-use version does not include geographic information due to privacy protection. Therefore, this dataset is used only for providing contextual information due to its limitations.

3.2 Economic Conditions & Demographics

The unemployment data are sourced from the U.S. Bureau of Labor Statistics' Local Area Unemployment Statistics. The primary economic condition proxy in this paper is the annual state-level unemployment rate. These rates are seasonally unadjusted, as seasonal effects are smoothed out when using annual averages.

State demographic characteristics are included to account for contextual variations over years. Census Bureau provides intercensal population estimates disaggregated by gender, race, and age for each year. From these, several demographic indicators are computed, including proportions of male, proportions of working-age (15-64) population, and proportion of racial groups.

3.3 COVID-19 Case Rate

A confirmed COVID-19 case is an important indicator of the severity of the disease spread. CDC COVID-19 Response has reported weekly increases in U.S. COVID-19 cases and deaths from January 23rd, 2020 to May 11th, 2023. This reporting is discontinued after the last update in June, 2023 as the COVID-19 public health emergency declaration expired (Centers for Disease Control and Prevention, COVID-19 Response, 2024). Weekly new COVID-19 cases counts from this dataset is aggregated to monthly and yearly frequencies. The data for 2023 is only available until May, when the policy ended; in order to avoid measurement error, observations for 2023 are excluded in the year-level COVID-19 data. For the similar reason, January 2020 and May 2023 are removed in the month-level sample. The COVID-19 case rate is calculated as the number of new cases during each month or year divided by the state population at the corresponding period.

3.4 Import Exposure Per Worker

Autor, Dorn, and Hanson (2013) have developed the Chinese import exposure per worker measure to quantify the impact of exogenous trade shock on local labour markets. Their shift-share composition is computed by distributing national import changes in each industry across regions based on how much each region contributed to national employment in each industry. This gives a weighted average of import exposure growth in $1000 USD, adjusted to the region's employment share in that industry. To analyze whether trade shocks influence the relationship between economic conditions and opioid mortality, I employ the import exposure measures of Autor et al. (2013), which are constructed at commuting zone (CZ) level to best represent local labour markets. To adapt this measure at the state level, aggregation is done by computing population-weighted averages of CZ import exposures, where each CZ's contribution was weighted by its share of the total state population. The existing import exposure data provide two sample periods: 1990-1999 and 2000-2007. State-level import exposure is then computed for the 2000-2007 period, which mostly overlaps with the sample period used in this paper.

Since CZ is not a type of administrative geographical unit, its location may not be within a single state as shown in Figure B6. Crosswalk files provide a probabilistic matching of CZs to states based on the 1990 CZ and county definitions (Dorn, 2025). Although analyzed at CZ level, the existing import exposure dataset already includes the state-CZ mapping, which is used for aggregation in this paper. After matching, import exposure data are available for 48 states. The remaining states–Alaska and Hawaii–and the District of Columbia are excluded in the subsequent analysis.

4 Descriptive Results

Table 1 provides the state-level summary statistics for all variables including demographic controls and their available sample periods.

Table 1: State-level summary statistics

	Mean	Std. Dev.	Min	Max	Observations	Sample Period
Unemployment Rate	5.33	2.10	1.90	13.80	1275	1999-2023
Any Opioid Death Rate	10.86	9.87	0.29	70.28	1275	1999-2023
Heroin&Synthetic Opioids Death Rate	6.92	9.83	0	66.80	1275	1999-2023
COVID-19 Case Rate (yearly)	9891.77	3602.87	1134.84	18780.53	153	2020-2022
COVID-19 Case Rate (monthly)	789.15	1027.43	0	9416.73	1989	Feb. 2020 - Apr. 2023
Δ Import Exposure Per Worker	2.58	1.21	0.54	5.56	48	2000, 2007
Proportion of Males	0.49	0.01	0.47	0.52	1275	1999-2023
Proportion of Working Age Population	0.65	0.02	0.60	0.74	1275	1999-2023
Proportion of White	0.80	0.13	0.25	0.98	1275	1999-2023
Proportion of Black	0.12	0.11	0.003	0.62	1275	1999-2023
Proportion of Asian	0.04	0.06	0.005	0.67	1275	1999-2023

Note: 1. Opioid death rate and COVID-19 Case Rate are both in per 100,000 population for more direct comparison here.

2. The table reports changes in imports from China to US per worker in USD$1000.

Fluctuations in the unemployment rate reflect major events that impact the broader economic conditions. In the early 2000s, the unemployment rate tends to center around 5%, indicating a relatively stable economy. In 2008, the financial crisis brought the U.S. economy to a downturn, damaging economic growth and financial market stability. Nearly all states during this time were impacted, and the unemployment rate spiked to a mean of approximately 9%, resulting in a more dispersed unemployment rate distribution (Figure B4). After 2011, the economy gradually recovered from the shock, and the average unemployment rate returned to 5% around 2016. A similar pattern occurred during the 2020 COVID-19 pandemic. The U.S. again faced an economic downturn and massive unemployment; however, this time states recovered more quickly. The average unemployment rate returned to a level close to its historical average before shocks.

From Table 1, the opioid death rate per 100,000 has high variations, partly due to substantial differences in the number of opioid deaths across states, especially in more recent years (Figure B3). Overall, the opioid death rate has been continuously increasing since 1999 without returning to its historical levels. Some states experienced particularly high death rates since 2020. The opioid death rate has a heavily right-skewed characteristic as shown in Figure B1. This confirms that in some years some states experienced disproportionately high death rates than others. The skewness is not reduced even after the log transformation (Figure B2), implying the high variation across states and over time remains substantial.

Both yearly and monthly COVID-19 case rates indicate widespread infection across states and potential increase over time. The aggregated Import Exposure Per Worker measure is constructed as the difference between the 2000 and 2007 levels and do not vary each year. The extent of state import exposure is determined by their percentile ranks in the aggregated exposure distribution. Three percentiles are identified to represent different levels of trade shock. The 40th-60th percentile represents moderate import exposure, the 30th percentile indicates low import exposure, and the 70th reflects high exposure. To confirm the accuracy of the aggregated import measure in identifying import exposure levels, states in all three selected percentiles are compared to those that contain more highly impacted CZs within their borders in Figure B6. The percentile-based approach effectively identifies impacted states, which are concentrated in the East and Southeast U.S.

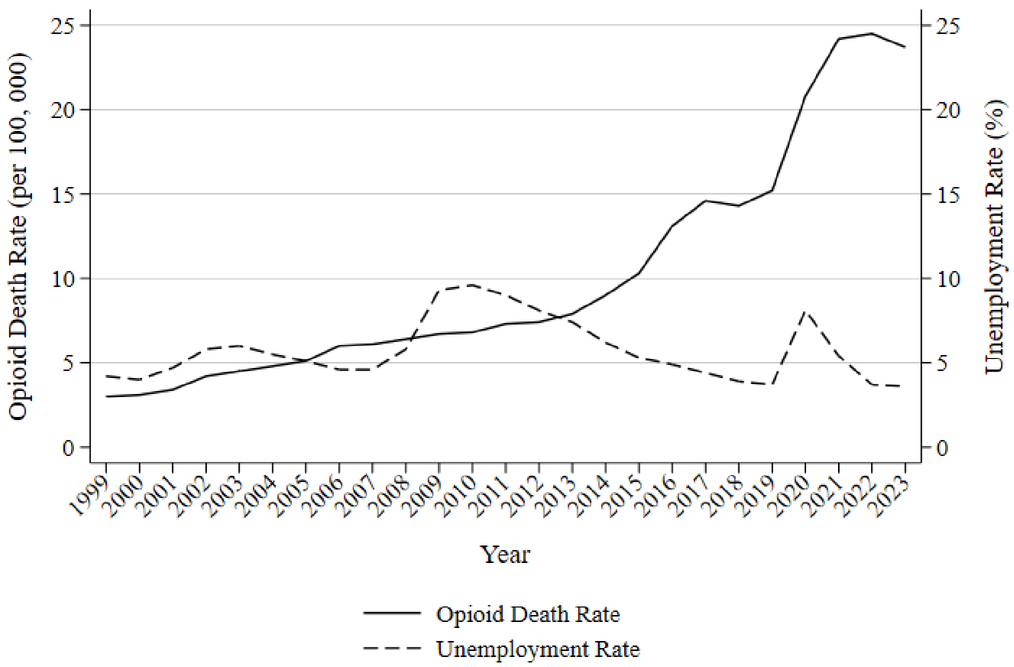

Figure 1: National any-opioid death rate and unemployment rate, 1999-2023

Figure 1 shows the movements of the any-opioid death rate and unemployment rate at national level. The two rates move in the same direction during 2000-2003, 2006-2010, and 2019-2023, covering the periods of the financial crisis and COVID-19 pandemic. Previous research commonly used the period 1999-2015 and found that the increase in the unemployment rate was associated with an increase in opioid or drug mortality in general (Hollingsworth et al., 2017; Ruhm, 2019; Carpenter et al., 2017; Brown & Wehby, 2019). However, opposite trends emerged during 2003-2006 and 2010-2019, periods prior to the financial shock and the recovery years after the crisis, making the relationship less clear and highlighting further assessments on the true cyclicality of opioid death.

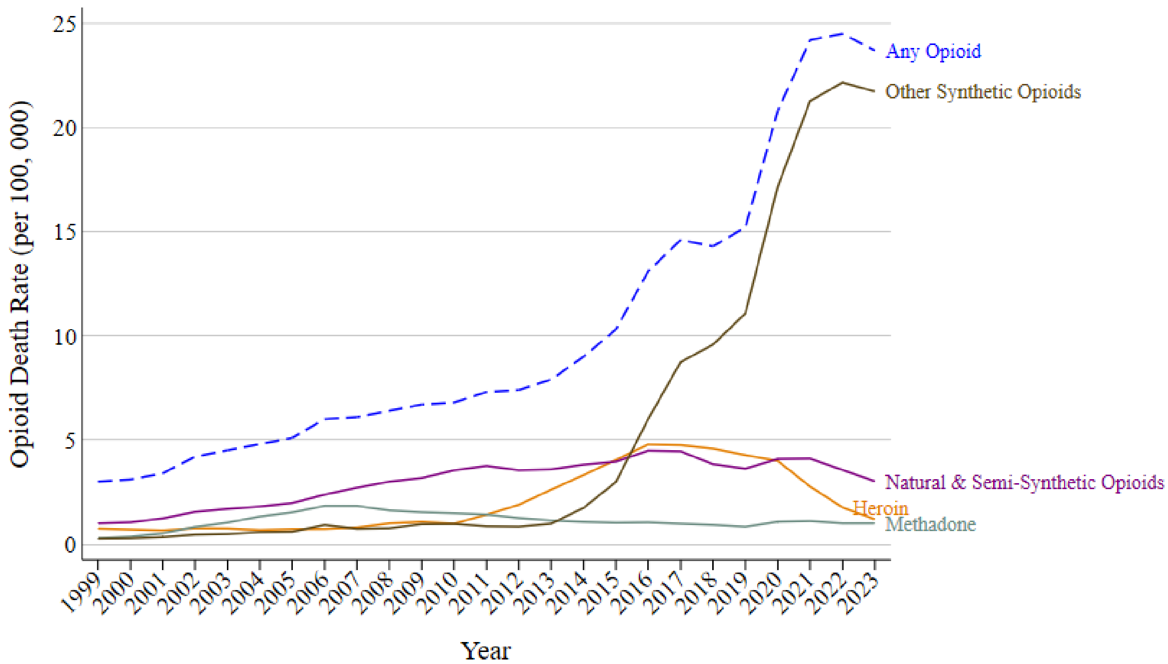

Figure 2: Opioid death rate by opioid type, 1999-2023

The increase in opioid death rate has been driven by different types of opioids over years. As shown in Figure 2 and Table A1, in a span of 25 years, natural and semi-synthetic opioids are involved in 36% of opioid deaths, and they are the main drivers of opioid deaths in the early 2000s. Starting in 2016, synthetic opioids involvement surpassed all other opioids, making it the most lethal type after 2015. Synthetic opioids are involved in 33% of opioid overdoes deaths over years. Heroin and methadone involvement are 21% and 15% of respectively. These changes mark transitions in the nature of the opioid crisis.

Table 2: Within and between-state variations of key variables, 1999-2023

	Mean	Std. Dev.	Min	Max	Observations
Unemployment Rate					
Overall	5.33	2.10	1.90	13.80	N = 1275
Between		0.99	3.04	7.09	n = 51
Within		1.76	1.94	12.65	T = 25
Any Opioid Death Rate per 100,000					
Overall	10.86	9.87	0.29	70.28	N = 1275
Between		5.01	2.76	28.61	n = 51
Within		8.53	-15.92	52.53	T = 25
Heroin & Synthetic Opioids Death Rate per 100,000					
Overall	6.92	9.83	0	66.80	N = 1275
Between		3.86	1.27	19.37	n = 51
Within		9.06	-11.84	54.35	T = 25

Note: N = Total sample observations, n = Number of states, T = Number of years

At the national level, there is a substantial variation in both the unemployment rate and the opioid death rate. Table 2 further decompose variations into between and within-state variations to discover the source of variability. The "Overall" row shows the summary statistics for each variable across all observations. The "Between" row shows the variation in state averages compared to the grand mean, calculated based on each state's average variable values across all time periods. The "Within" values show the state deviation from their own average over the 25 years with the global mean added back to make results comparable. Minimum and maximum values represent the smallest and largest deviations from the means.

Unemployment rates between states show moderate differences, with the state-level averages ranging from the lowest 3.04% to the highest of 7.09%. For opioid death rates, there are large and more persistent differences across states, likely reflecting structural, demographic, or policy-related factors that are unique to each state. All three variables exhibit higher within-state variations compared to between-state variation, suggesting that more changes in opioid mortality and unemployment occurred within states over time rather than between them. Characteristics here suggests the implementation of a model that utilizes the within-state variations to better capture the relationship between the unemployment rate and opioid mortality.

5 Empirical Approach

I employ a two-way fixed effect (TWFE) model to examine the relationship between thee unemployment rate (a proxy for economic conditions) and opioid mortality. I examine the relationship using two opioid definitions - one, deaths involving any opioids, and two, heroin and synthetic opioids combined. To obtain a robust view of the relationship, the analysis is implemented in three parts to examine the relationship during the full sample period and during times of trade and pandemic shocks that adversely impact the labour market.

In the first part, I analyze the relationship using the full sample to discover the general cyclical pattern. Using a similar TWFE strategy as Hollingsworth et al. (2017) with additional demographics control, the model has the following specification:

$$Y_{it} = \beta U_{it} + \gamma' X_{it} + \eta_i + \delta_t + \mu_{it} + \epsilon_{it} \tag{1}$$

where Y_{it} is the outcome variable representing any-opioid death rate or heroin and synthetic opioid death rate per 100,000 population in state i and year t. Unemployment rate U_{it} is available for state i and year t. State fixed effect η_i is included to control for the unobserved time-invariant factors between states. Year fixed effect δ_t controls for common nationwide trends that could influence opioid mortality across states at the same time. Considering the relatively long sample period, fixed effects may not effectively control for all confounding factors. The model also includes X_{it}, a vector of demographic controls. An additional concern is that states may have different underlying trajectories in opioid death rates. States could have increasing opioid deaths over years regardless of labour market shocks due to prevalent drug use behaviours or poor healthcare. Labour markets could improve in some states but stay stagnant in other states, therefore again contributing to different evolutions of opioid mortality. To account for these factors, state-specific time trends μ_{it} are included.

The second part considers the influence of the COVID-19 pandemic in increasing the unemployment rate during 2020-2022. The model is implemented using the year-level sample. Given that COVID-19 infection has great month-to-month variations, the month-level sample covering February 2020-April 2023 is also used. To examine whether the effect of unemployment rate on opioid mortality varies with the COVID-19 severity, COVID-19 confirmed case rate $COVID_{it}$ and the interactions between COVID-19 severity and unemployment rate $U_{it} * COVID_{it}$ are added in the model. To improve interpretability, the COVID-19 case rate is scaled to the percentage unit instead of per 100,000 population when running the model. Since the COVID-19 pandemic occurred in the short-run, the impact of the underlying state trajectories is less evident. To prevent overfitting, state-specific time trends are removed. The following model is used in this section:

$$Y_{it} = \beta_1 U_{it} + \beta_2 COVID_{it} + \beta_3 U_{it} * COVID_{it} + \gamma' X_{it} + \eta_i + \delta_t + \epsilon_{it} \tag{2}$$

In the third part, I analyze whether the impact of the unemployment rate on opioid mortality differs in states with higher Chinese import exposure. Import exposure levels here are represented by dummy variables $ImportExposure_i$. This variable indicates whether states have low (30th percentile), medium (40th-60th percentile), and high (70th percentile) import exposure levels. The interaction between the unemployment rate and import exposure level $U_{it} * ImportExposure_i$ is included. The dummy variable $ImportExposure_i$ itself is not included in the model to avoid perfect collinearity with the state fixed effects. As a result, the independent impact of import exposure when holding all else constant cannot be observed. An alternative approach is to remove the state fixed effects, but this would expose the model to confounding factors regarding time-invariant state characteristics. This is a tradeoff. Since the goal of this analysis is to assess how import competition modifies the relationship between unemployment and opioid mortality, the model does not include the import exposure dummy but keeps state fixed effects. The model specification then takes the form:

$$Y_{it} = \beta_1 U_{it} + \beta_2 U_{it} * ImportExposure_i + \gamma' X_{it} + \eta_i + \delta_t + \mu_{it} + \epsilon_{it} \tag{3}$$

Here I assume that states maintain the same exposure rankings during 2000-2007 because the Chinese import competition evolves gradually over time, and trade exposure depends on state industrial structure which does not shift dramatically in the short-run. Autor et al. (2013) have used the 2000-2007 cumulative import changes to construct the import exposure values. They find that exposure to Chinese imports led to declines in both manufacturing and non-manufacturing employment, and subsequent impacts on household income and transfer benefit payments. Although these effects may not directly lead to an economic downturn, the import exposure helps examine to what extent the relationship between the unemployment rate and opioid mortality varies when states face exogenous labour market shocks.

6 Results

6.1 General Cyclical Pattern

Table 3 reports the results from estimating the base TWFE model and the preferred model (1) using the full sample period of 1999-2023. Both models include demographic controls to account for gender, age, and race structure over time. Standard errors in both models are clustered at the state-level. Columns (1)-(2) show results for any opioid-related overdoes deaths, while columns (3)-(4) focus on heroin and synthetic opioid deaths combined. For both outcomes, the model fit improves to over 90% when using the preferred model specification.

The results suggest a negative relationship between the unemployment rate and any-opioid death rate. The TWFE specification in column (1) provides a negative and insignificant estimate (-0.167). When only state fixed characteristics and common trends are controlled for, unemployment is predicted to have limited and insignificant association with any-opioid deaths. However, when allowing each state to have its own linear time trend, the coefficient becomes significant and larger in magnitude but still suggests a procyclical pattern, that is, an increase in the unemployment rate (economic downturn) is associated with lower any-opioid deaths. The preferred model results in column (2) suggest that a one-percentage-point increase in the unemployment rate is associated with a decrease in any-opioid death rate by 0.53 per 100,000, equivalent to a 5% decline.

There are a few probable reasons for the changes in scale and significance. First is that state-specific time trends help address omitted variable bias as there could be underlying state characteristics that impact opioid mortality but that are unrelated to unemployment, such as a poor healthcare system. Second, states can have pre-existing differences if over-presciption is prevalent in some states. In terms of model design, since state-specific time trends capture additional unobserved underlying factors, the model fit is improved, and the variance of the residuals is reduced. The model now focuses almost entirely on short-term, within-state variations. This results in a smaller estimate standard error, making the estimation more precise.

A similar pattern is seen for heroin and synthetic opioids deaths. The base TWFE specification in columns (3) yields a negative and insignificant estimate of -0.178, similar to that of any-opioid death outcome. Column(4) reports a significant estimate of -0.579 which is more pronounced than -0.530 for any opioid deaths. This implies that a one percentage point increase in the unemployment rate is associated with a 0.579 reduction in heroin and synthetic opioids death rate per 100,000, translating to a reduction of 8%.

Overall, results based on both opioid definitions suggest a negative relationship between opioid overdose deaths and unemployment. A slightly stronger relationship appears for deaths involving heroin and synthetic opioids.

Table 3: The estimated impact of state-level unemployment on opioid mortality.

	Any Opioid		Heroin& Synthetic Opioids	
	(1)	(2)	(3)	(4)
Unemployment Rate	-0.167	-0.530**	-0.178	-0.579***
	(0.302)	(0.236)	(0.289)	(0.200)
Mean of Dependent Variable	10.87	10.87	6.92	6.92
Adjusted R^2	0.758	0.907	0.751	0.912
State FEs	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓
State-specific Time Trends		✓		✓
Demographic Controls	✓	✓	✓	✓
Standard Error	Cluster-Robust	Cluster-Robust	Cluster-Robust	Cluster-Robust
Observations	1275	1275	1275	1275

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6.2 Cyclical Pattern During COVID-19 Pandemic

Table 4 reports results for estimating model (2) at year level from 2020 to 2022. State fixed effects, year fixed effects, and demographic controls are included in the model. State-specific time trends are removed in the specification here because state contextual structure shifts minimally in a short duration. COVID-19 case rate and unemployment rate are centered to provide more intuitive interpretations. The results here examine whether the cyclicality changes when states experience varying COVID-19 severity.

Columns (1)-(3) present estimates for deaths involving any opioids. Columns (1) and (2) show positive relationships between COVID-19 severity and opioid deaths, as well as between unemployment and opioid deaths. In column (3), the model includes both the unemployment rate and its interaction with COVID-19 case rate. COVID-19 severity continues to have a positive and statistically significant association with opioid deaths, indicating states with above-average COVID-19 severity also face elevated opioid mortality. During this period, unemployment appears to exacerbate the opioid overdose deaths. Holding COVID-19 severity at its 2020-2022 average, a one-percentage-point increase in the unemployment is associated with 1.039 increase in any opioids deaths per 100,000. Both COVID-19 and unemployment have their own, separate effect on opioid mortality. When estimating their interaction, the estimate is positive (0.520), suggesting that the positive relationship between unemployment and opioid mortality is stronger under more severe COVID-19 conditions. However, this interaction estimate is small and statistically insignificant, providing limited evidence that COVID-19 severity modifies the influence of unemployment on any-opioid deaths during this period.

Columns (4)-(6) apply the same approach as above for deaths involving heroin and synthetic opioids. Similarly, COVID-19 and unemployment have independent relationships with opioid mortality. Both relationships are positive when holding other factors at their average level. However, there is no strong evidence that the impact of unemployment on heroin and synthetic opioids-involved deaths varies with COVID-19 severity, as the interaction estimate remains statistically insignificant.

Table 5 replicates the analysis at month level for any-opioids related deaths. A large portion of monthly heroin and synthetic opioids-involved deaths are censored due to low counts, so this outcome will not be included. Column (2) shows that COVID-19 severity is negatively associated with opioid mortality at month level, however, the estimate -1.265 is small and weakly significant. When including unemployment rate and their interaction, the impact of COVID-19 severity is absorbed by the unemployment rate. The coefficient estimate of unemployment rate remains positive in this case but with a much smaller scale compared to that using year-level data. Despite lower death counts at the month level, this is also likely due to less variation in the opioid death rate which makes it hard to capture the true relationship. A one-percentage-point increase in unemployment rate is only associated with 0.049 increase in monthly opioid death rate when COVID-19 case rate is at its average level. Again, there is no strong evidence that COVID-19 severity modifies the countercyclical relationship between unemployment and opioid mortality.

From these results, the sign of the coefficient estimates for unemployment rate has reversed during the period with heightened COVID-19 infection, and the cyclicality becomes countercyclical. In other words, an increase in unemployment rate is associated with higher opioid mortality rates. However, COVID-19 severity itself does not appear to modify this relationship, suggested by the consistently small and statistically insignificant interaction, regardless of time granularity. The reversal likely reflects the influence of distress related to the pandemic that is not captured by state COVID-19 severity. Reduced mobility due to stringent intervention policies, healthcare system response delays, and insufficient labour market support may play more direct roles in amplifying opioid overdose and better explain the shift in the cyclicality than COVID-19 severity per se.

Table 4: The estimated year-level impact of unemployment on opioid mortality and the modifying impact of COVID-19 severity, 2020-2022.

	Any Opioid			Heroin& Synthetic Opioids		
	(1)	(2)	(3)	(4)	(5)	(6)
Unemployment Rate	0.773**		1.039**	0.792**		0.983**
	(0.292)		(0.396)	(0.296)		(0.379)
COVID-19 Case Rate		30.960**	41.931***		29.818*	40.212**
		(14.951)	(14.972)		(14.922)	(14.911)
Unemployment Rate * COVID-19 Case Rate			0.520			-1.231
			(4.385)			(4.263)
Adjusted R^2	0.969	0.969	0.972	0.968	0.968	0.971
State FEs	✓	✓	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓	✓	✓
Demographic Controls	✓	✓	✓	✓	✓	✓
Standard Error	Cluster-Robust	Cluster-Robust	Cluster-Robust	Cluster-Robust	Cluster-Robust	Cluster-Robust
Observations	153	153	153	153	153	153

Note: Unemployment rate and COVID-19 case rate are centered using mean values.

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: The estimated month-level impact of unemployment on opioid mortality and the modifying impact of COVID-19 severity, Feb. 2020 - Apr. 2023.

	(1)	(2)	(3)
	Any Opioid	Any Opioid	Any Opioid
Unemployment Rate	0.046***		0.049***
	(0.006)		(0.006)
COVID-19 Case Rate		-1.265*	-0.146
		(0.667)	(0.899)
Unemployment Rate * COVID-19 Case Rate			0.504
			(0.517)
Adjusted R^2	0.878	0.872	0.878
State FEs	✓	✓	✓
Year FEs	✓	✓	✓
Demographic Controls	✓	✓	✓
Standard Error	Cluster-Robust	Cluster-Robust	Cluster-Robust
Observations	1989	1989	1989

Note: Unemployment rate and COVID-19 case rate are centered using mean values.

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6.3 Cyclical Pattern During Trade Shock

Table 6 reports the results of estimating model (3) for any opioid-involved deaths and heroin and synthetic opioids-involved deaths during 2000-2007. The model is applied to three separate cases where the unemployment rate interacts with indicators that classify states as having high, medium, or low import exposure. Results are reported in Panels A, B, and C respectively.

The unemployment rate estimates in Panel C suggest that in states that are not under low import exposure, the increase in unemployment rate is associated with declines in opioid mortality. The relationship is stronger for heroin and synthetic opioids-related deaths due to a statistically significant result. Specifically, as the unemployment rate increases by one percentage point, the heroin and synthetic opioids-related death rate decreases by 0.167 per 100,000. Low import exposure has minimal modifying effects on the relationship between unemployment and both opioid mortality definitions. However, given that both interaction estimates do not appear significant, there is a lack of evidence on whether states that face low import exposure see a meaningfully different opioid overdose response to increasing unemployment.

Panel B reports results for states with medium-level import exposure. Among states with less than or above medium-level import exposure, a one-point increase in the unemployment rate is associated with a decrease of 0.144 per 100,000 in heroin and synthetic opioids-involved deaths. The estimate for any opioid-involved death is also negative and similar in magnitude though it is not statistically significant. The interaction terms suggest mixed and weak modifying impact of medium-level import exposure. There is insufficient evidence to conclude with confidence that states facing medium-level of import exposure experience higher opioid mortality.

In states with high import exposure as reported in Panel A, the relationship between unemployment and opioid mortality becomes less procyclical when facing high import exposure. The positive and statistically significant interaction estimates in both columns indicate that the negative association between unemployment and opioid deaths observed in less-exposed states is attenuated in high-exposure states. For deaths involving heroin and synthetic opioids, the actual association between unemployment and mortality remains negative but becomes smaller in magnitude (-0.065). For any-opioid deaths, the actual association turns slightly positive (0.078). Although the baseline effect of -0.165 is not statistically significant, this implies that high import exposure likely shifts the cyclicality of opioid mortality, transforming an otherwise negative relationship to a neutral or positive one.

Overall, these findings suggest that import competition could modify the influences of unemployment on opioid mortality. In less exposed states, the association between economic downturns and opioid deaths is not changed by trade shocks. In highly exposed states, the negative relationship between worsening economic conditions and opioid mortality becomes weaker, and unemployment may instead coincide with stable or increasing opioid deaths.

Table 6: The estimated modifying impact of Import Exposure on opioid mortality by state import exposure percentiles, 2000-2007.

	(1) Any Opioid	(2) Heroin & Synthetic Opioids
Panel A: High Import Exposure		
Unemployment Rate	-0.165	-0.170**
	(0.122)	(0.067)
Unemployment Rate * High Import Exposure	0.243**	0.105*
	(0.116)	(0.053)
Adjusted R^2	0.937	0.838
Panel B: Medium Import Exposure		
Unemployment Rate	-0.138	-0.144**
	(0.122)	(0.064)
Unemployment Rate * Medium Import Exposure	0.050	-0.042
	(0.119)	(0.074)
Adjusted R^2	0.936	0.837
Panel C: Low Import Exposure		
Unemployment Rate	-0.088	-0.167**
	(0.126)	(0.073)
Unemployment Rate * Low Import Exposure	-0.109	0.039
	(0.112)	(0.059)
Adjusted R^2	0.936	0.837
Mean of Dependent Variable	10.84	6.89
State FEs	✓	✓
Year FEs	✓	✓
State-specific Time Trends	✓	✓
Demographic Controls	✓	✓
Standard Error	Robust	Robust
Observations	384	384

Note: 1.States are classified into exposure groups based on their import exposure measure: high exposure includes states above the 70th percentile, medium exposure includes those between the 40th and 60th percentiles, and low exposure includes states below the 30th percentile. 2. Considering the smaller sample size, demographic controls here do not include proportion of black to avoid over-specification.

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

7 Robustness Checks

The general cyclical pattern of opioid mortality appears to be procyclical. This relationship reverses during economically challenging times such as during the COVID-19 pandemic and periods of substantial import competition. Two robustness checks are conducted to confirm the consistency of the procyclical pattern, including using alternative economic condition proxies and estimating using subsamples split by time.

7.1 Alternative Economic Condition Proxies

Although the unemployment rate is widely used as the proxy for economic conditions because of its short-run variability, it does not always perfectly represent the economic conditions. By definition, the unemployment rate excludes people who are not actively looking for work, and this could underestimate the actual economic disruption. To check the robustness of the findings, I replicate the analysis in Section 6.1 by replacing the unemployment rate with two alternative economic condition proxies, labour force participation rate (LFPR) and employment-to-population ratio (EPR). The model specification is the same as model (1).

Table A2 shows the estimation results. Panel A reports the results using the LFPR as the explanatory variable. Both coefficients are positive, suggesting that higher workforce participation is associated with increased opioid death rate, consistent with a procyclical pattern. Coefficient in column (1) is not statistically significant while in column(2) it gains slightly more significance. This is likely due to relatively low variation in LFPR. Panel B shows that using EPR provides similar results. Because EPR measures employment–the inverse of unemployment–it is expected that the coefficients become positive. In this case both coefficients are statistically significant. Notably, the estimated coefficients using EPR for both opioid mortality outcomes (0.521 and 0.606) are similar to those using the unemployment rate (0.530 and 0.579), reinforcing the procyclical pattern of opioid mortality.

7.2 Rolling Regression

Since this study covers a 25-year span, the relationship between economic conditions and opioid mortality may evolve over time. To examine the sensitivity of the results to different sample periods, a rolling regression is performed by sequentially regressing the any-opioid death rate per 100,000 on the unemployment rate, extending the sample by one additional year at each step. The model specification follows model (1). Figure B5 shows the regression estimates and their 95% confidence intervals.

The result reveals a dynamic evolution of the relationship between unemployment and opioid mortality changing through distinct phases. By the mid-2000s, the relationship is weakly negative and the effect is nearly zero. This period coincides with the first wave of the opioid crisis that is dominated by prescription opioids. Such pattern in earlier years is reasonable as opioid overdose in this phase is primarily driven by over-prescription rather than local economic fluctuations.

The relationship gradually turns positive after the Great Recession when a doubled unemployment rate is concurrent with rising drug deaths. It is during this period that theories like "deaths of despair" emerges to provide an explanation on factors related to declining economic opportunities. The period of 2013-2014 coincides with findings from most studies that show a positive relationship between economic downturns and opioid mortality (Hollingsworth et al., 2017). The estimated magnitude of the state-level relationship typically is around 0.24 (Hollingsworth et al., 2017; Ruhm, 2019; Brown & Wehby, 2019), which is roughly the upper bound of the confidence interval during 2013-2014 in Figure B5. Few studies use a comprehensive opioid death definition to examine this relationship; for example, Hollingsworth et al. (2017) exclude heroin and synthetic opioids in their analysis, and do not have extensive analysis beyond 2016. Despite different measurement and time windows, there is some consistency in the relationship during this period. Although the data cannot distinguish the effect from zero, evidence here implies that unemployment is related to the crisis.

The turning point comes after 2016 when the opioid crisis has a structural transition to illicit opioids. The relationship shows a large reversal and the magnitude is more than doubled. The descriptive results (Figure 1) show that opioid overdose deaths during this period are not closely tied to short-run economic fluctuations, and they continue to worsen even when the unemployment rate declines in the late 2010s. The rolling regression estimation likely captures this negative relationship. The magnitude of the negative relationship continuously increases and stabilizes after 2020. This questions the expectation that physical health outcome is a manifestation of mental stress that stems from economic distress. Instead, during these periods, drug supply side shifts and reduced healthcare access due to the pandemic could be increasingly crucial in driving overdose deaths.

Overall, the relationship remains negative in most sample periods, with the exception of a brief positive relationship around 2013-2014. Data constraints contribute to uncertainty in the estimates, reflected in the wide confidence intervals and statistical insignificance in some periods. However, the coefficient estimates become significant when extending the sample to after 2020. Despite some possible shifts around 2014, the broader pattern is largely procyclical. This also underscores the importance of considering sample-period sensitivity and more underlying factors when analyzing the relationship.

8 Discussion

This paper has three major findings on the relationship between economic conditions (using unemployment rate as the proxy) and opioid mortality. Some of the limitations will be discussed in this section.

The first finding is a negative relationship between the unemployment rate and opioid mortality. A procyclical pattern holds for both overall opioid deaths and deaths involving largely illicit opioids. This pattern appears counterintuitive, as it suggests that during certain periods, higher unemployment may coincide with lower overdose deaths. There are several potential explanations. One reason focusing on individual-level mechanism is that economic improvements may increase disposable income and purchasing power, potentially increasing the access and demand for opioids. Conversely, during periods of elevated unemployment, reduced income and social activities may limit such access, especially for illegal drugs (Bretteville-Jensen, 2011; Catalano et al., 2011) and presumably prescription drug diversion. This mechanism could alter the relationship as illicit opioids, such as fentanyl, have driven the opioid crisis in more recent years. Another possibility is that supply-side dynamics may not align perfectly with economic cycles, especially for the less observed illicit drug market. Supply-side shocks, such as the entering of fentanyl into heroin markets, have a strong force in shaping the drug environment (Ciccarone, 2017; Zoorob, 2019), possibly overpowering unemployment shifts in recent years.

Recent changes in the opioid crisis are not considered in studies that report a countercylical relationship between unemployment and opioid mortality. Notably, prior analysis focus on a limited time window of 1999-2015, potentially miss important trends. For example, during 2010–2019, the U.S. unemployment rate steadily declined, but opioid-related deaths continued to rise. The robustness check on the stability of the relationship (Figure B5) also indicates that results can be sensitive to the sample period. Estimates based on a specific time window could be biased and unrepresentative. While some literature has questioned the countercyclical pattern, it largely concludes that the association has weakened in recent years (Ruhm, 2019). Although this paper does not establish a causal link, it suggests that the cyclicality is likely to reverse and become unstable over time. In addition, considering the continuous upward trends in opioid mortality, there is tentative indication that the driver of opioid mortality has shifted. Alongside short-run changes in unemployment, factors such as drug availability, healthcare access, and mental health have become increasingly important.

The second finding provides additional evidence that the relationship is unstable over time. During 2020-2022, the COVID-19 pandemic period, the relationship between unemployment and opioid mortality becomes positive, shifting from procyclical to countercyclical. The pandemic impacts all states in the U.S. during this period when almost every state experiences a rapid increase in COVID-19 infection. For states with an average level of COVID-19 severity, the relationship not only becomes positive but also the magnitude becomes larger compared to the general association across states. It is likely that the relationship between unemployment and opioid mortality changed during the pandemic. However, there is no evidence on whether the relationship differs significantly across states with varying levels of COVID-19 case rates. As the COVID-19 case rate is a broad measure of the severity of the disease, the way the pandemic actually impacts the economy and labour market activities could relate more to health regulations and the stringency of policies.

The third finding is that medium-run labour market disruptions driven by import competition barely amplify the adverse impact of unemployment on opioid mortality. Specifically, high import competition slightly moderates the negative relationship between unemployment and opioid mortality, though only observed for deaths involving heroin and synthetic opioids. Medium and low import exposure show limited evidence of modifying the baseline relationship. These results suggest structural economic shocks like import competition may influence how unemployment relates to opioid deaths, though this influence is relatively weak. Few studies in the literature provide theoretical reasons or empirical evidence for such a modifying effect; however, some indirect evidence suggests a possible link. Pierce and Schott (2020) find that after the granting of the 2000 Permanent Normal Trade Relations (PNTR) to China, U.S. counties that are more exposed to Chinese imports experience significant increases in accidental poisoning, which is closely related to drug overdose deaths. It appears evident that trade liberalization can lead to changes to mortality rate through labour market outcomes. Venkataramani, Bair, O'Brien, and Tsai (2020) indicate that structural employment shocks can lead to persistent socioeconomic distress that eventually increases vulnerability to opioid-related harm. These studies imply that exogenous shocks on economic conditions are likely to modify opioid mortality through structural unemployment changes, consistent with the modest interactive effects observed in this paper.

It is important to acknowledge that this paper faces two major limitations. One is opioid mortality data availability. Due to data censoring, the aggregated death counts from CDC Wonder are heavily masked at county level. The finest, yet not perfect, granularity is obtained at the state level. Opioid mortality has fewer variations compared to prior analysis that uses restricted individual-level Multiple Cause of Death (MCOD) files (Hollingsworth et al., 2017; Ruhm, 2019) or county-level data (Pierce & Schott, 2020). The results are also sensitive to the level of aggregation. County-level data yields smaller estimates for the unemployment rate than state-level data (Hollingsworth et al., 2017). However, such difference is not huge (0.19 for county and 0.24 for state). County-level models are able to capture more confounding factors and within-state variations but do not necessarily provide more accurate estimates as counties can be too small to fully reflect macroeconomic effects (Hollingsworth et al., 2017). The two data levels show different dimensions of the economic condition and opioid mortality relationship, rather than outperform the other.

The data availability constraints prevent the use of alternative opioid-related mortality definitions for robustness checks because of the low counts. When comparing annual total opioid deaths from CDC Wonder and the MCOD, CDC Wonder provides lower yearly totals (approximately 1000 lower in 2023). Technically, CDC WONDER presents aggregated data based on standardized reporting categories and ICD-10 coding. During aggregation, certain records might be grouped differently or excluded.

The second limitation is the potential bias of the TWFE estimator in the presence of heterogeneous treatment effect. A TWFE regression is frequently run to implement difference-in-difference (DiD) comparison in settings of multiple periods and staggered treatment adoption across units. The TWFE estimator is consistent when assumptions on homogeneous treatment effect and parallel trends hold. However, treatment is often likely to be heterogeneous across units or time. As a result, the TWFE estimator no longer reveals the true treatment effect. Instead, it becomes a weighted average of all pairs of two-period, two group DiD estimators, and the TWFE estimator can pick up the wrong counterfactuals (Goodman-Bacon, 2021).For example, earlier-treated units are used as control groups for later-treated units. Through this process, irregular negative weights can be assigned to each comparison, leading to a false negative estimate (de Chaisemartin & D'Haultfœuille, 2020).

Most of this literature proposed solutions to address the bias in binary TWFE estimator by decomposing the estimator or re-assigning weights to group-time comparisons or re-computing weights of estimators (Goodman-Bacon, 2021; Callaway & Sant'Anna, 2021). Less solutions are proposed regarding continuous treatment, such as unemployment rate. The proposed estimator of Callaway and Sant'Anna (2021) has several advantages in extending DiD to settings where treatment varies in intensity, rather than being strictly treated and untreated. This mitigates the biased weighting issues in TWFE models. Notably, all proposed estimators still rely on the parallel trends assumption which is difficult to prove in a continuous setting. Besides, the Callaway and Sant'Anna (2021) estimator is designed for settings with clearly defined pre- and post-treatment periods, which is not applicable to the purpose of this paper—to estimate the overall relationship between continuous changes in unemployment rate and opioid deaths.

Several questions remain. While this analysis focuses on the contemporaneous relationship between unemployment and opioid mortality, future studies might consider the lagged effects of unemployment. The adverse impact of unemployment on substance use, mental health, and financial security could take effect years after a downturn. It is also possible that widespread prolonged unemployment has more impact than short-term job losses. Investigating these lagged dynamics would provide a more comprehensive understanding of how economic shocks unfold over time.

The unemployment rate provides a high level indication of the economic conditions. Shifts in economic conditions likely impact intermediate factors that are linked more directly with health outcomes. Individual level changes can be further considered to comprehensively reveal the causes of economic distress, such as job quality, health insurance, or long-term labour force detachment, to better capture how economic marginalization contributes to overdose risk. Future research could also explore the underlying mechanisms linking economic conditions to opioid mortality, such as changes in drug use bahaviour, healthcare access or the illicit drug market dynamics. Understanding these pathways would also help clarify whether the observed associations are driven primarily by demand-side or supply-side factors.

9 Conclusion

Economic conditions play unavoidable roles in influencing the opioid overdose outcomes. Previous research generally finds that opioid overdose deaths increase during economically challenging times, which is often represented by rising unemployment rates. Such findings suggest a countercyclical pattern. This paper shows a procyclical pattern, that is, opioid mortality declines when economic conditions worsen at the state level in the U.S. during 1999-2023. However, this relationship is not uniform over time; it becomes sensitive to sample periods and either reverses or weakens in the presence of major external shocks, such as the COVID-19 pandemic and rising import competition.

Although unemployment has a negative and periodically unstable association with opioid mortality at the aggregate level, the harm that unemployment could bring to individuals, such as financial insecurity, social isolation and hopelessness are still risk factors for opioid misuse and overdose. These conditions make individuals susceptible to overdose incidents and undermine their likelihood of recovering from opioid misuse. The procyclical patterns discovered in this paper do not suggest that economic downturns protect people from the opioid crisis; rather, these patterns are an indication that unemployment likely impacts overdose outcomes through more complex mechanisms. Further studies are needed to explain these shifting patterns at both the individual and aggregate level, thus contributing to more effective policy in dealing with the opioid crisis.

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Appendices

A Tables

Table A1: National-level average proportion of opioid deaths involving each type of opioid, 1999-2023

	Mean	Std. Dev.	Min	Max
Heroin	21%	0.10	5%	39%
Natural & Semi-synthetic Opioids	36%	0.11	13%	52%
Methadone	15%	0.09	4%	31%
Synthetic Opioids	33%	0.31	9%	92%
Observations: T = 25				

Note: One opioid overdose death can involve more than one type of opioids. Therefore, the proportions here are non-mutually exclusive. Deaths attributed to the type of opioid are identified based on any mention of a specific type of opioid.

Table A2: The estimated impact of state-level unemployment on opioid mortality using alternative economic condition proxies, 1999-2023.

	(1) Any Opioid	(2) Heroin & Synthetic Opioids
Panel A: Labour Force Participation		
Labour Force Participation Rate	0.390	0.489*
	(0.265)	(0.287)
Adjusted R^2	0.903	0.911
Panel B: Employment to Population		
Employment to Population Ratio	0.521**	0.606***
	(0.206)	(0.208)
Adjusted R^2	0.908	0.913
Mean of Dependent Variable	10.87	6.92
State FEs	✓	✓
Year FEs	✓	✓
State-specific Time Trends	✓	✓
Demographic Controls	✓	✓
Standard Error	Cluster-Robust	Cluster-Robust
Observations	1275	1275

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B Figures

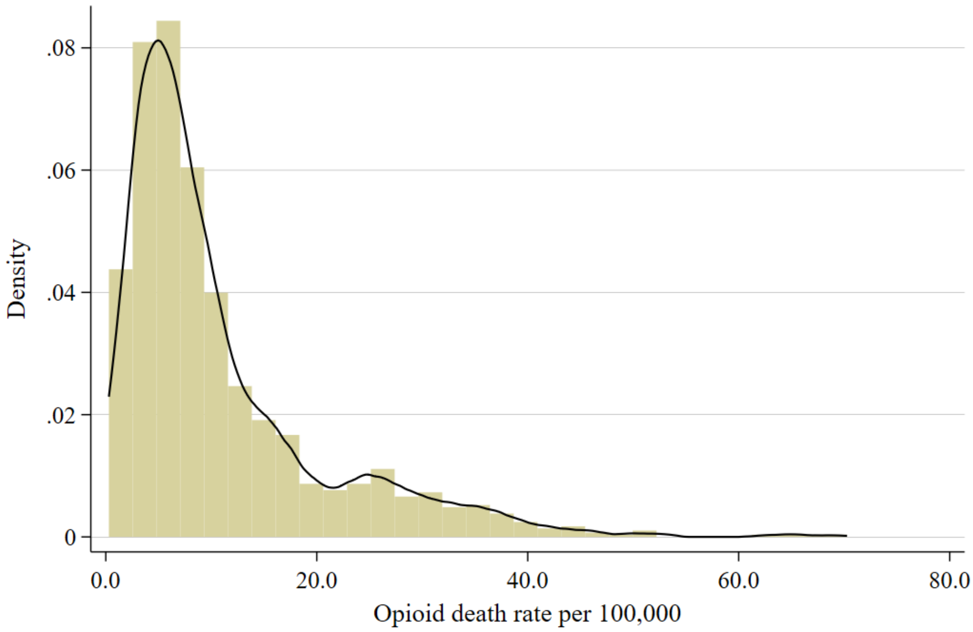

Figure B1: State-level opioid death rate distribution, 1999-2023

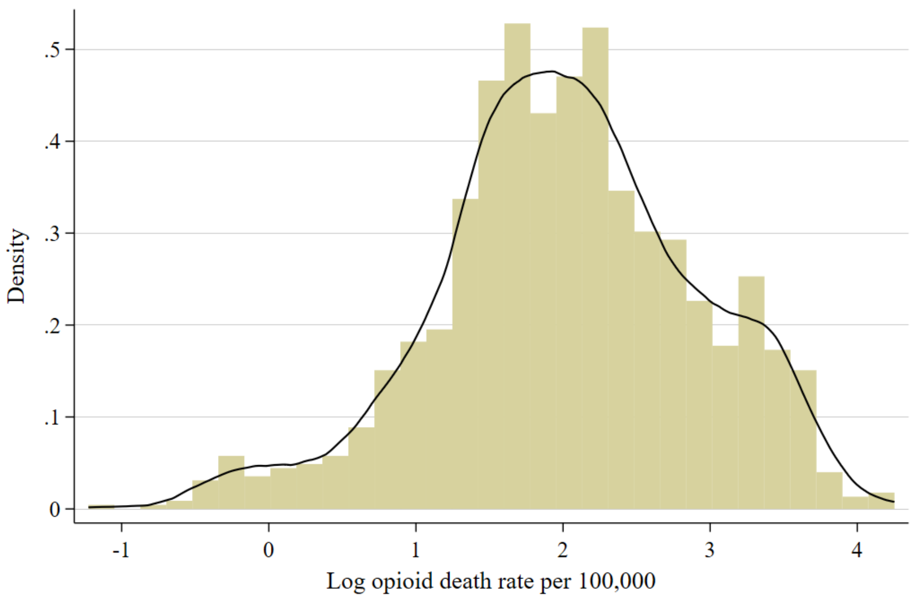

Figure B2: State-level log transformed opioid death rate distribution, 1999-2023

Note: State-level death counts ranging from 1 to 9 are suppressed. Suppressed counts are replaced with 5, the midpoint of the suppression range.

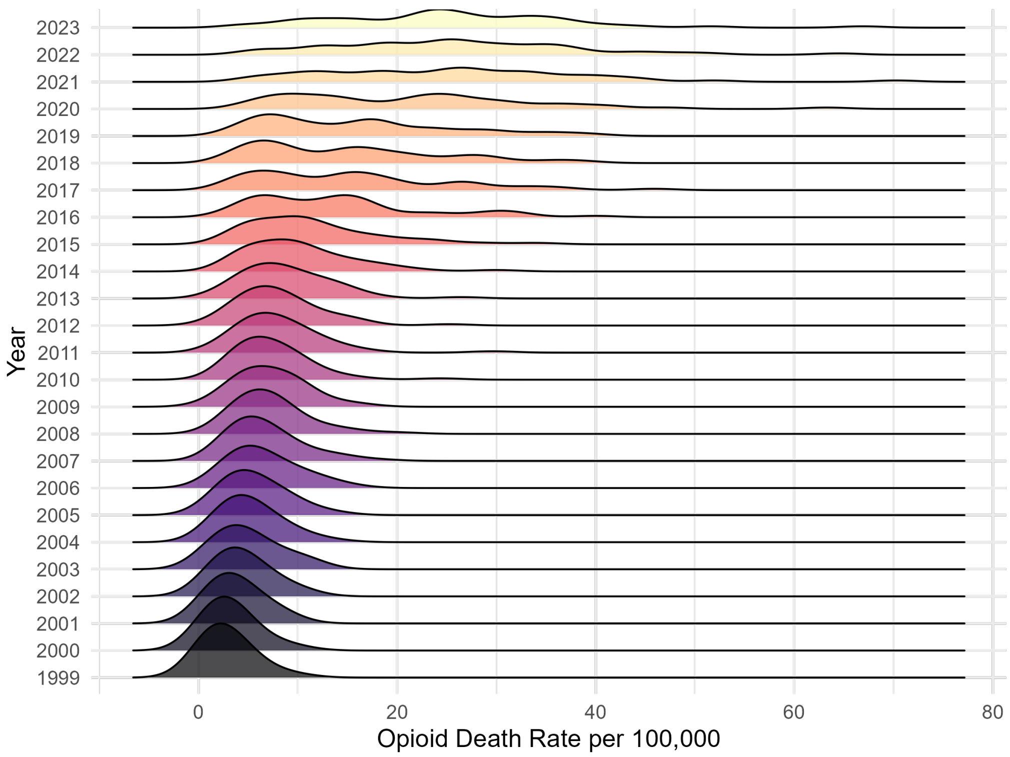

Figure B3: Distribution of state opioid death rates by year - any opioid

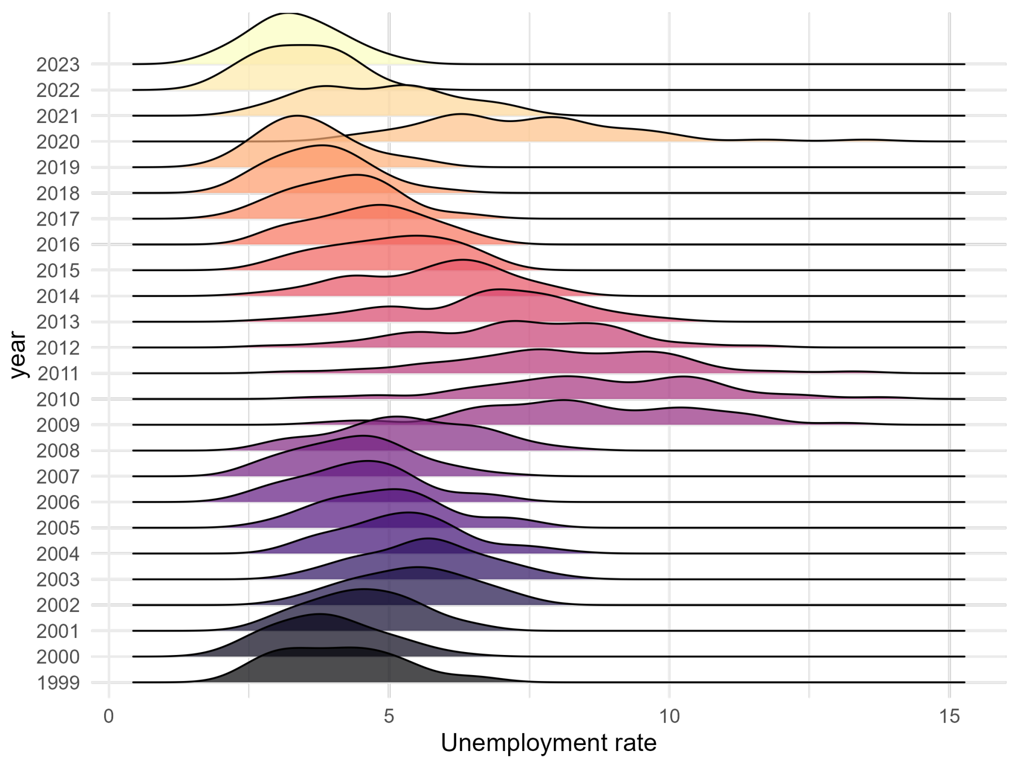

Figure B4: Distribution of state unemployment rate by year

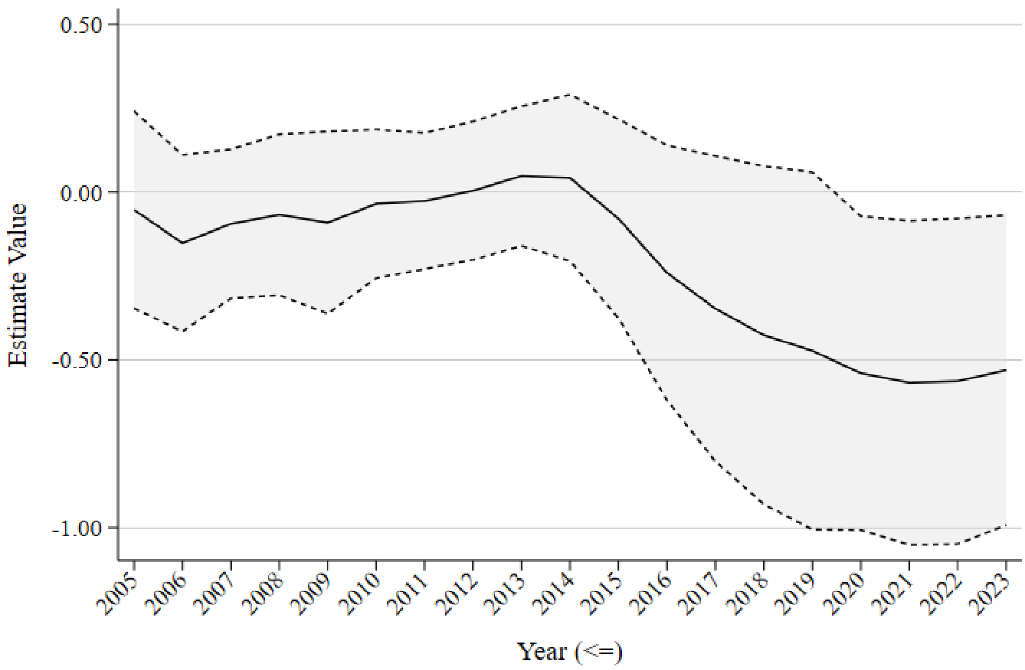

Figure B5: Rolling regression results with 95% confidence interval (any opioid)

Note: Estimate values remain largely unchanged when suppressed monthly opioid death counts are imputed with values of 2, 5, or 8.

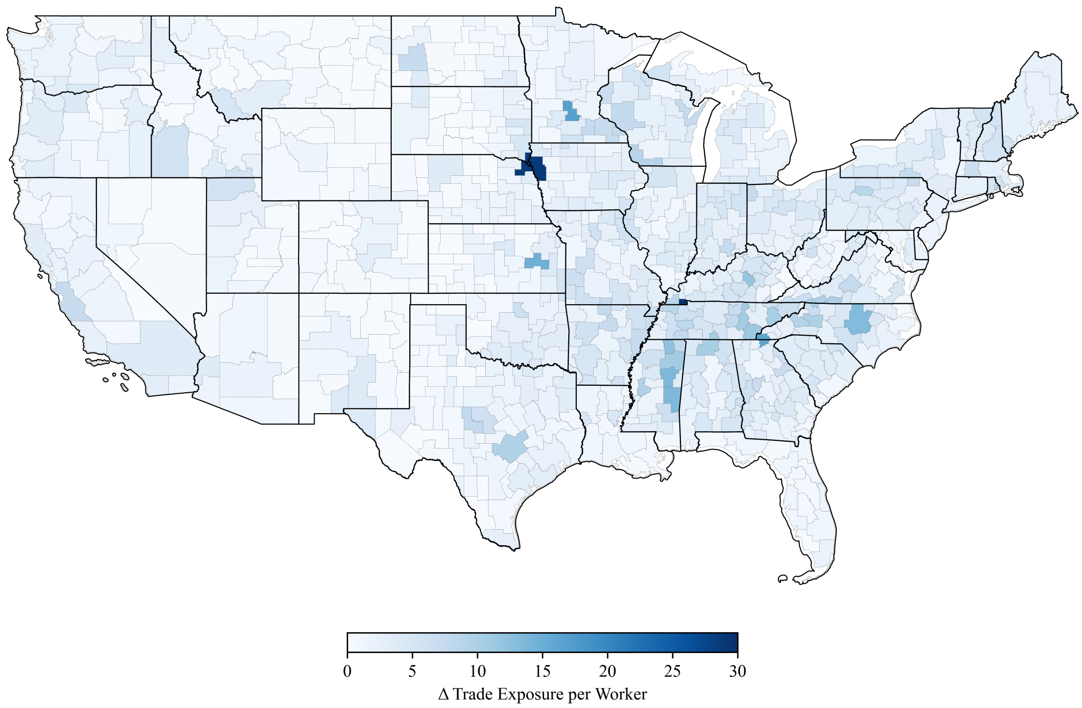

Figure B6: Changes in import exposure per worker ($1000) during 2000-2007 within the mainland U.S.