



ABANDONED BY COAL,  
SWALLOWED BY OPIOIDS?

By Wang Yi ,2020/2/18



- I. Introduction
- II. Background
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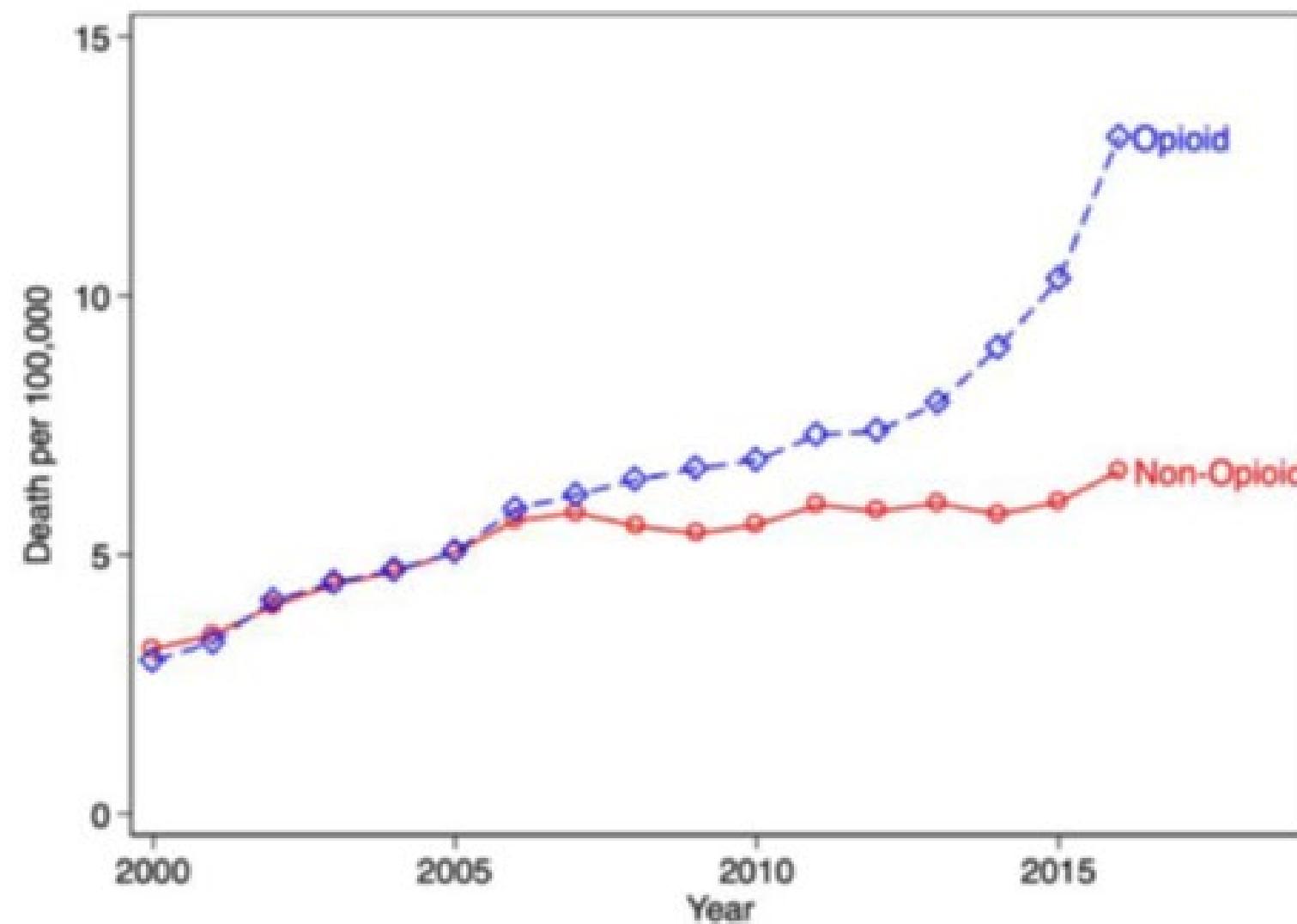
# I. Introduction

## I

## Introduction

- Opioid use has become a major health crisis in the United States.

Figure 1: Death Rate by Opioid Types



Death rates from opioid overdoses have risen especially rapidly as shown in Figure 1.

*Data Source: Center of Disease Control Mean weighted by population*

*Death Code: Any opioid (T40.0-T40.4, T40.6), opium (T40.0), heroin (T40.1), natural and semisynthetic opioids (T40.2), methadone (T40.3), and synthetic opioids other than methadone (T40.4)*

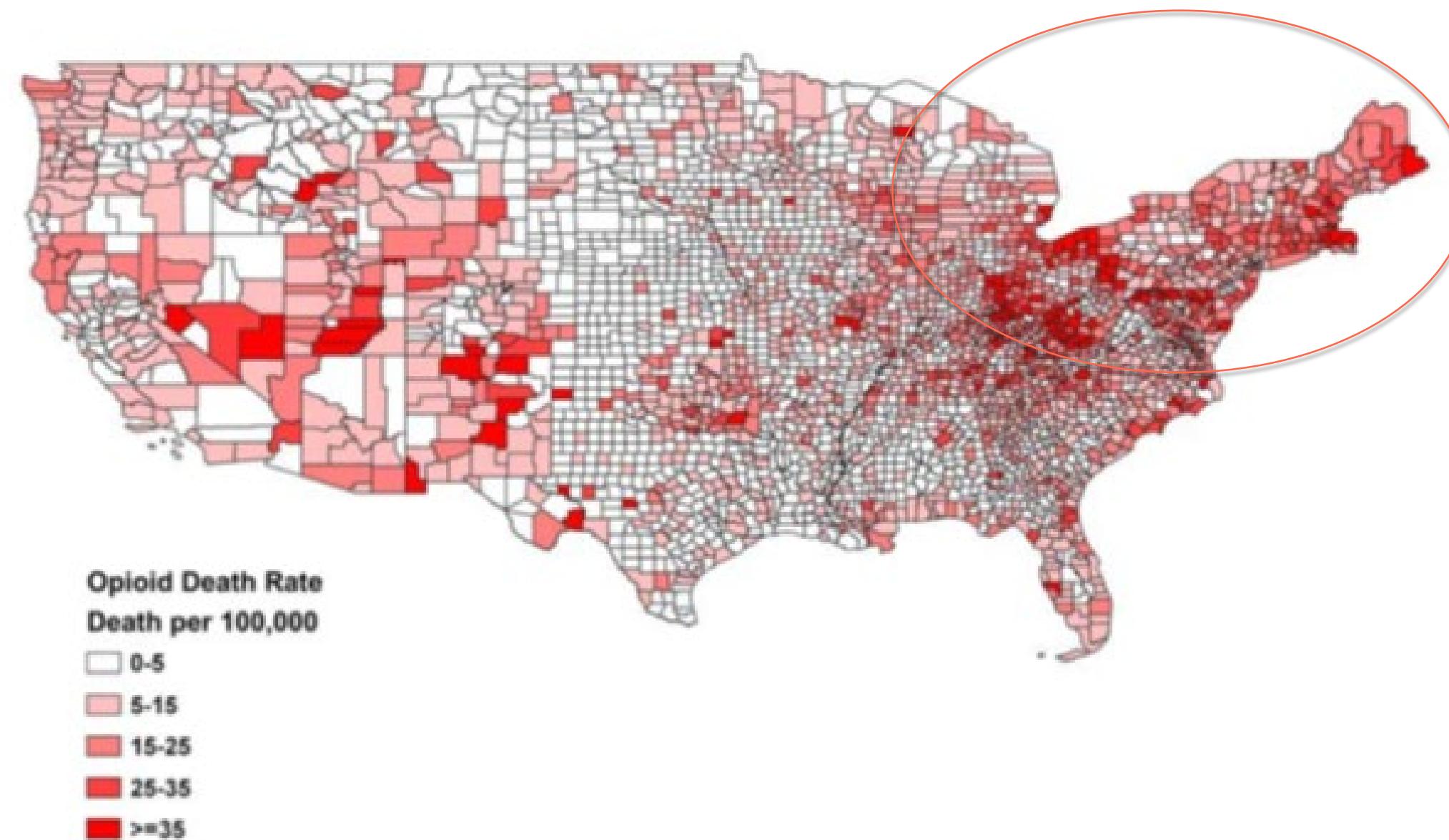
*Non-Opioid: Include other records with underlying cause of death being identified as overdose death, e.g. Cocaine (T40.5)*

## I

## Introduction

- Opioid mortality is geographically concentrated

Figure 2: Geographical Distribution of Opioid Mortality



East coast, Rust Belt regions, and the Southwest in Figure 2.

Appalachian region: has been especially hard hit.

Economies are heavily dependent on coal mining.

## Introduction

- The U.S. energy market has been undergoing a massive transformation.

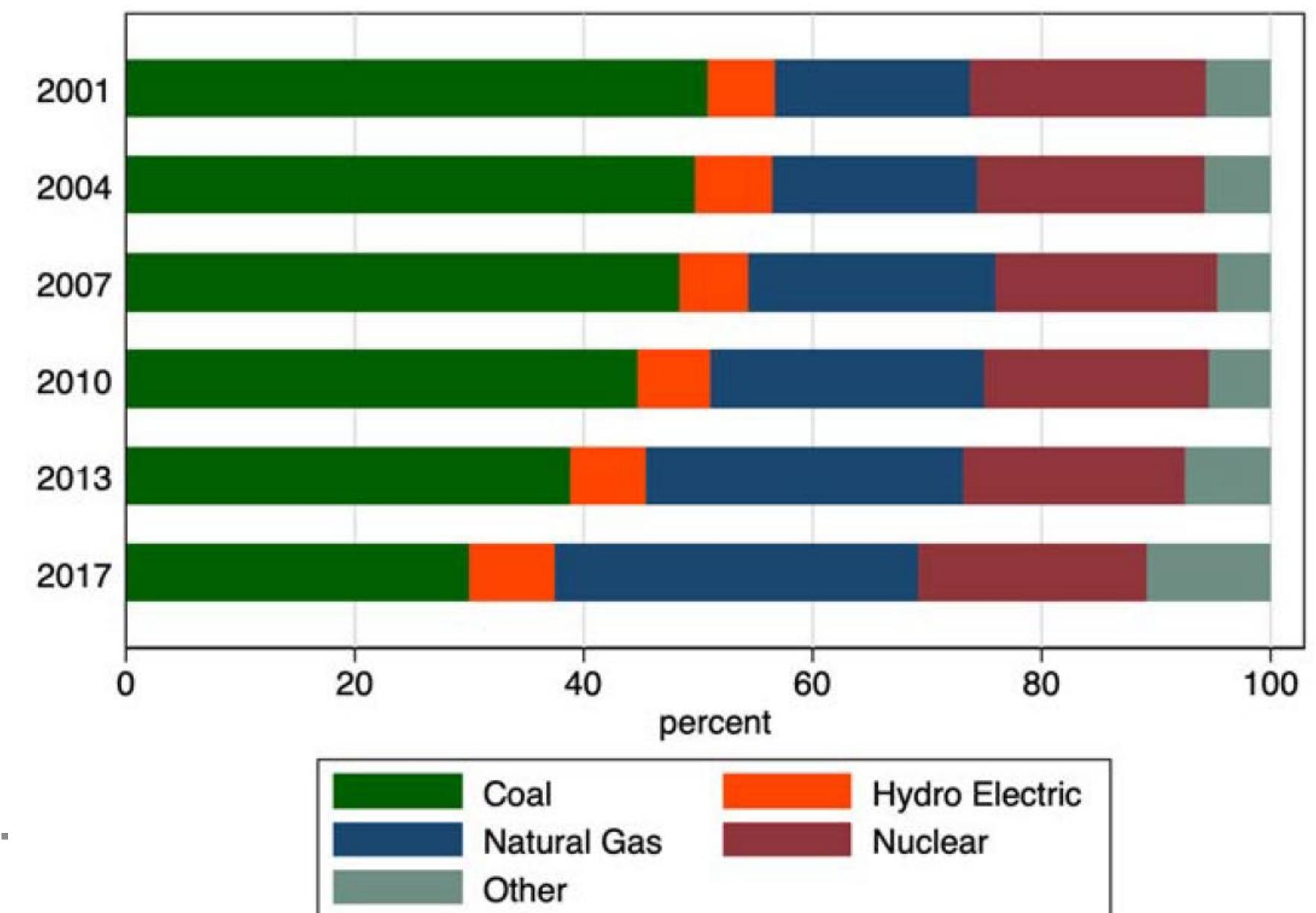
**Coal**, once the dominant fuel source for **electricity generation**

**Technological advances** in natural gas production

A sharp fall in the price of natural gas

Replaced by natural gas as the largest fuel source for electricity production.

Figure 3: Energy Consumption In Electricity Sector, by Energy Source



*Data Source: U.S. Energy Information Administration*

# Introduction

## ● Decline in coal-related employment in U.S.

**Overall Decline in coal demand**, a 28% decrease in total production and a 34% decline in coal-related employment in U.S.

Coal production in the United States has been **shifting from** Eastern coal mines (Appalachian regions) to Western regions (the Powder River Basin).

Eastern coal mines

the higher sulfur content

lower productivity

primarily underground mined coal

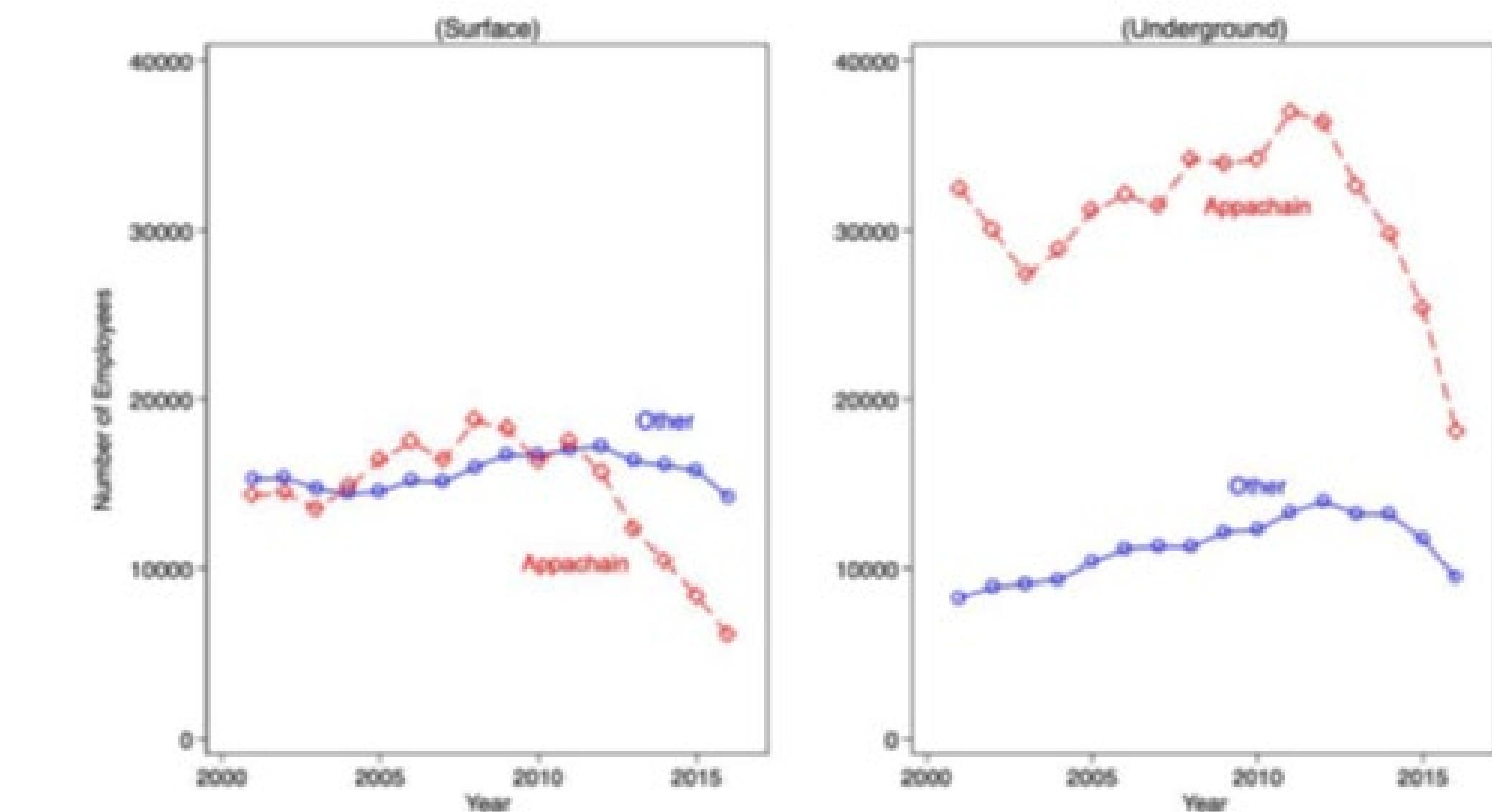
Western coal mines

the lower sulfur content

higher productivity

primarily surface mined coal

Figure 4: Employment Change by Regions and Mine Types



Data Source: U.S. Energy Information Administration

Show:

The decline in coal mining employment since 2000.

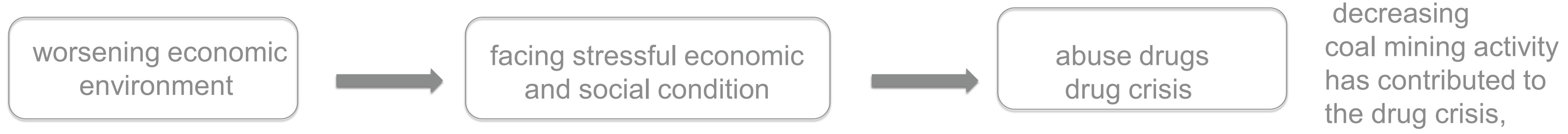
The job loss in underground mines is much larger.

More layoffs of coal miners from both surface and underground mines in the Appalachian regions.

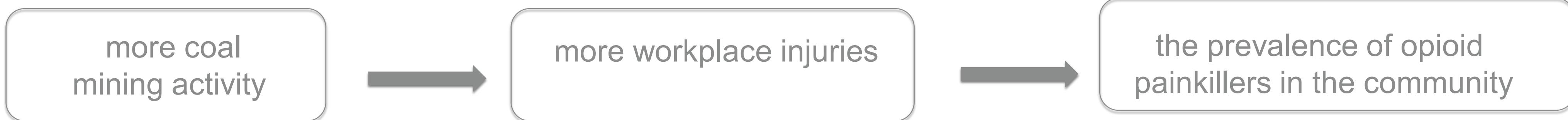
## Introduction

- Two opinions

**“abandoned by coal, swallowed by opioids.”—— “deaths of despair” hypothesis**



**The positive relationship between coal mining activity and opioid death**



policies to reduce reliance on coal could indirectly help reduce opioid addiction and mortality.

# I

## Introduction

- Study

the relationship between **opioid death rates** and **county coal mining activity**.

**Dependent variable:** the opioid overdose death rate

**The key independent variable:** the share of coal miners in the county labor force

**Potential endogeneity** in the labor share :IV

constructing a Bartik-style variable to instrument for coal mining employment.

**Main conclusion:** In the coal-producing counties

The share of coal miners in the workforce increases 1%----- the opioid mortality by 0.192%.

The impact is stronger among underground than surface coal mines.

## II. Background

## Background

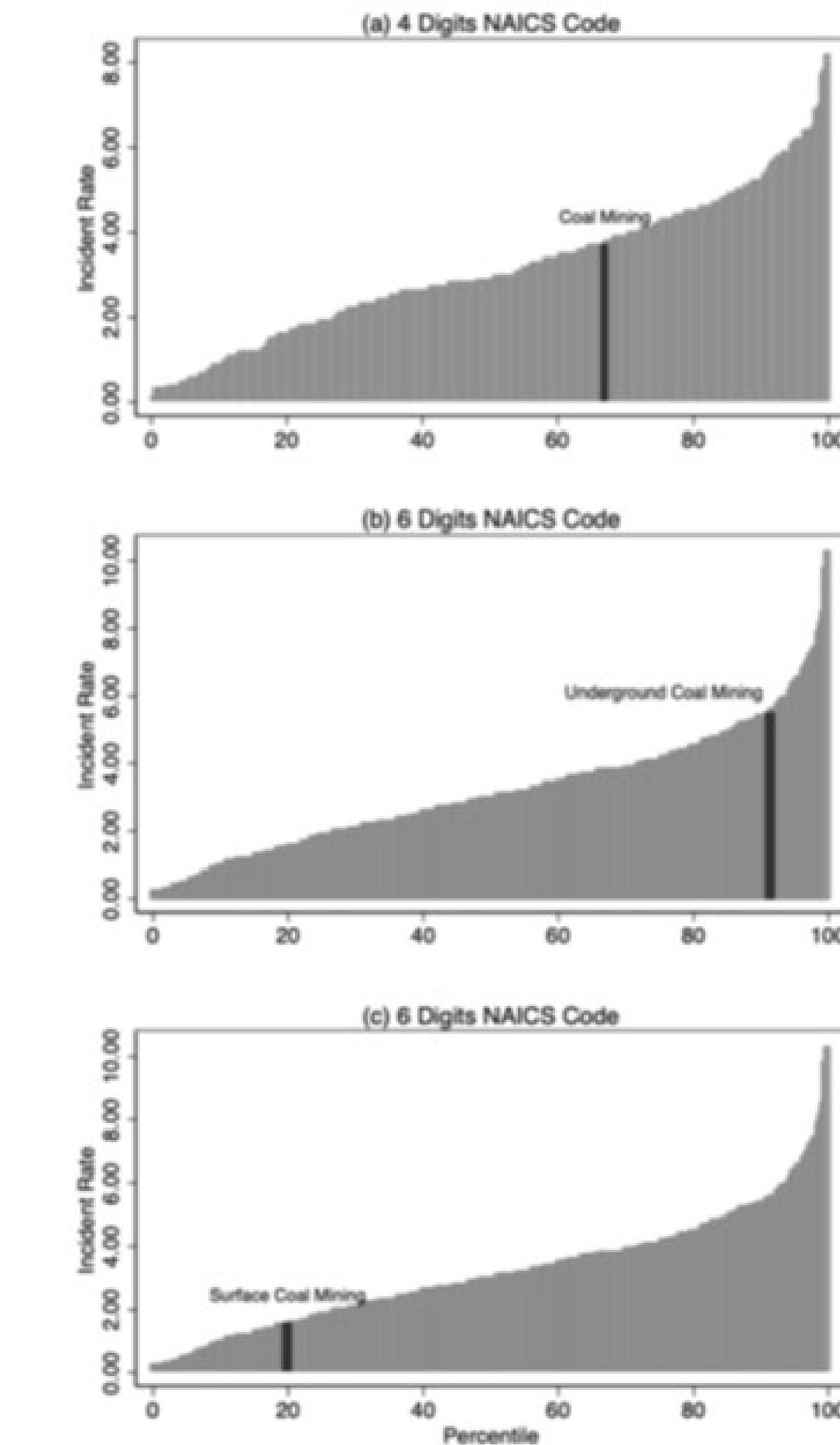
- Reason: **overdose death rates** have risen dramatically over the past two decades.
  - a heightened focus on pain management (对疼痛管理的高度重视)
  - aggressive marketing by drug companies (制药公司的激进营销)
  - proliferation of powerful synthetic opioids (强力合成阿片类药物的扩散)
- the coal industry has experienced the most severe decline in the history of mining in the United States. (煤炭行业经历了美国采矿史上最严重的衰退)
- Idea of “deaths of despair.”
  - rising unemployment and declining economic conditions in Appalachian coal mining communities —— higher rates of opioid addiction and death. (失业率的急剧上升和经济状况的衰退可能导致阿片类药物上瘾和死亡的比例上升)

## Background

- heterogeneous effect of employment growth and wage changes on opioid overdoses in different industries. (就业增长和工资变化对不同行业阿片类药物过量的异质性影响)
- it is also possible that work related injuries could also drive increased opioid use.  
(工作有关的伤害也可能导致阿片类药物的使用增加)

**Underground coal mining** is an especially **hazardous** occupation requiring workers to spend long periods of time in cramped working conditions.

Figure 5: Incident Rate Non-fatal Injuries and Illness of Coal Industry in 2017



Data Source: Bureau of Labor Statistics, U.S. Department of Labor, Survey of Occupational Injuries and Illnesses, in cooperation with participating state agencies.

NAICS Code: Coal mining, 2121, Underground coal mining, 212112, Surface coal mining 212111.

All comparison between same NAICS level.

The incidence rates represent the number of injuries and illnesses per 100 full-time workers and were calculated as:  $(N/EH) \times 200,000$  where :

N : number of injuries and illnesses.

EH : total hours worked by all employees during the calendar year.

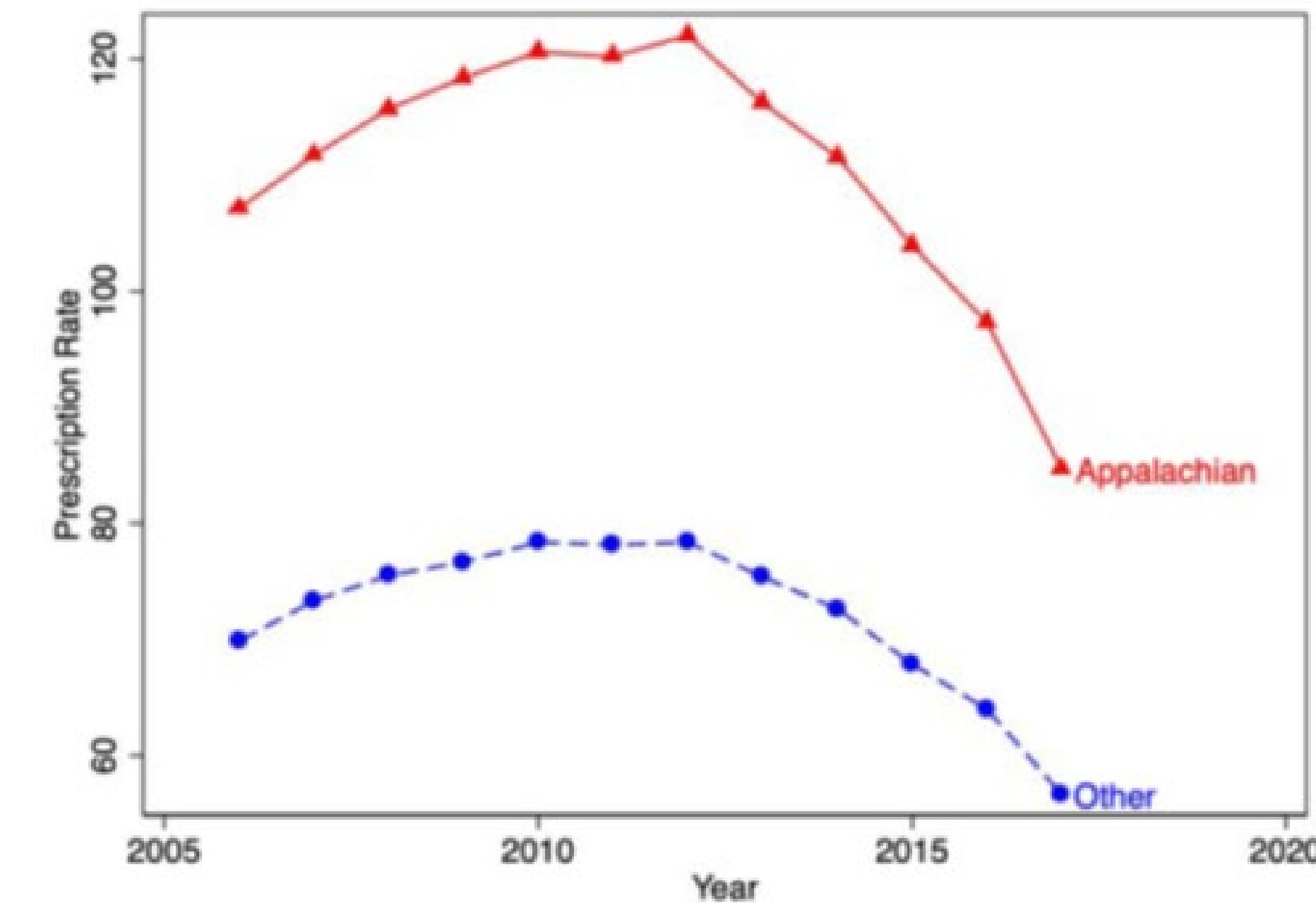
200,000: base for 100 equivalent full-time workers (working 40 hours per week, 50 weeks per year).

劳动统计局2017年记录的同一NAICS级别上，全部行业的非致死性工伤和疾病排名

## Background

- the prescription rate of opioid in the Appalachian region is almost double the prescription rate in other regions.  
(阿巴拉契亚地区阿片类药物的处方率几乎是其他地区处方率的倍。)
- Starting from 2013, the prescription rate of opioids has been decreasing dramatically. This is because states began to review Prescription Drug Monitoring Program (PDMP) data and implement pain clinic regulation.  
(从2013年开始，阿片类药物的处方率急剧下降。这是因为各州开始审查处方药监测计划 (PDMP) 数据并实施疼痛临床监管)
- Appalachian region had abnormally **high opioid death rates**.

Figure 6: Prescription Rate in Appalachian and Other Regions



Data Source: CDC Opioid Prescription Map.

Prescription Rate: Opioid prescriptions written for every 100 Americans

## Background

- The difficult working environment may contribute to injuries or chronic pain that leads to increased reliance on painkillers, including opioids. (困难的工作环境可能导致受伤或慢性疼痛，从而导致对止痛药（包括阿片类药物）的依赖性增加。)
- In addition, the culture of coal mining may make it difficult for injured coal miners to take time off from work, especially as jobs are being cut back due to reduced demand for Appalachian coal. (煤矿文化可能使受伤的煤矿工人难以请假，特别是由于阿巴拉契亚煤炭需求减少，工作岗位正在减少。)
- The relationship between opioid use and labor force participation is complex. Mutual effects between employment and opioid usage. (阿片类药物的使用与劳动力参与之间相互影响)

### III. Conceptual Framework

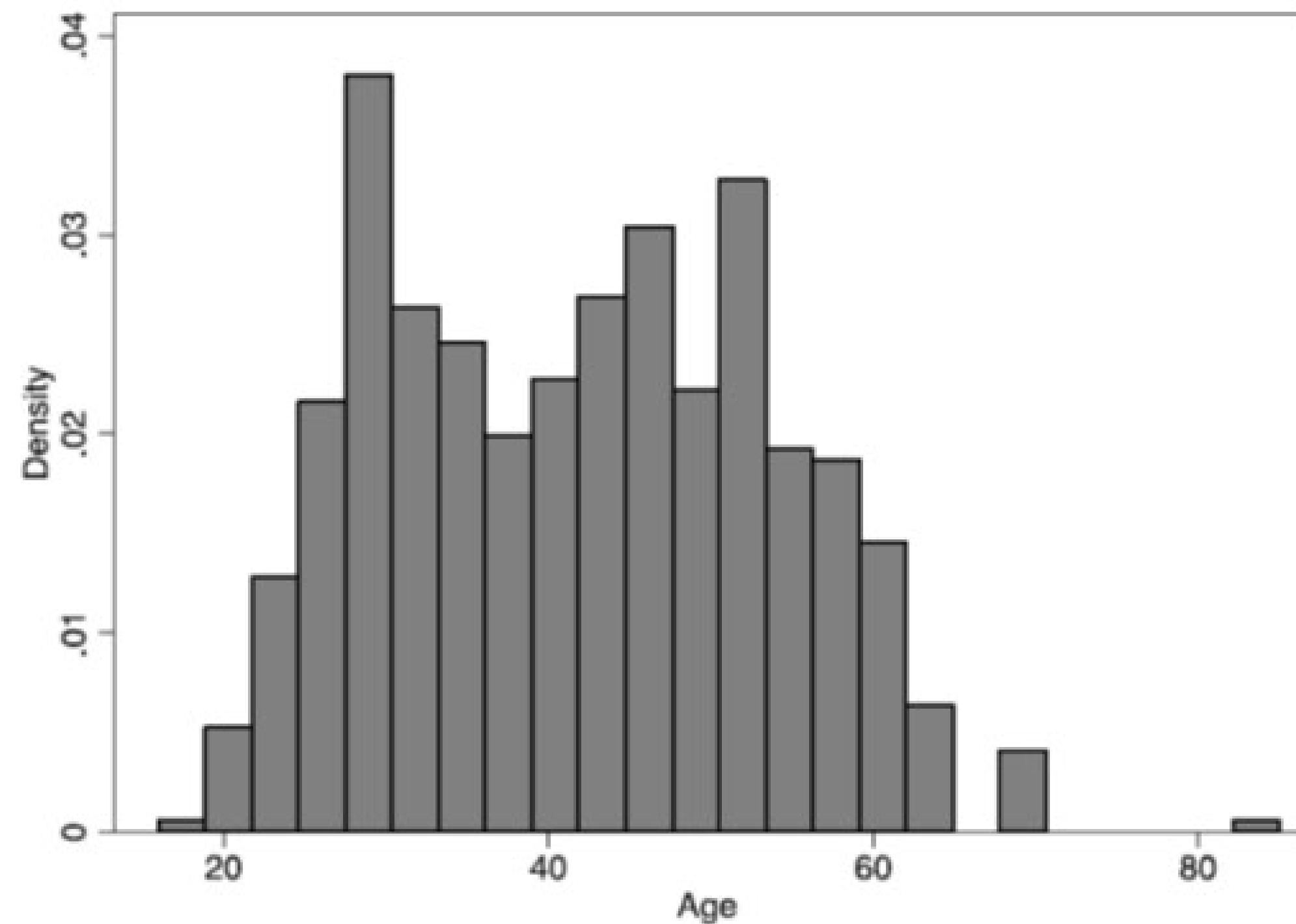
## Conceptual Framework

The total number of underground coal miners dropped by 45%

The number of surface coal miners by 41%

Concentrated on male workers with educational outcomes of high school degree (负面就业冲击主要集中在具有高中及以下学历的男性工人)

Figure 7: Age Distribution of Coal Miners



*Data Source: Current Population Survey.*

70% of the coal miners are between 25 and 50 years old

## Conceptual Framework

### Opinions 1

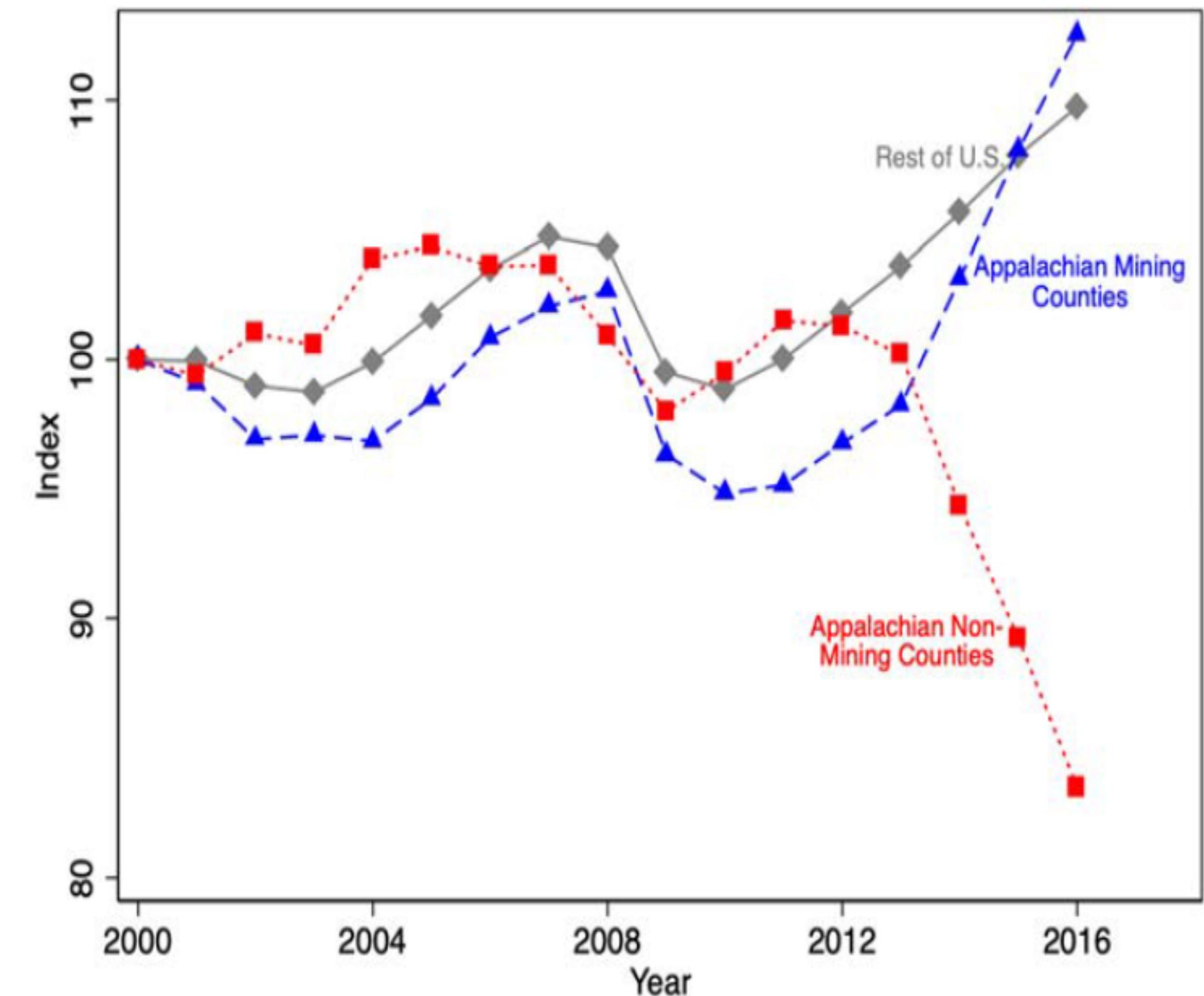
The loss in coal employment has led to broader **spillover effects** which have suppressed overall economic growth in the relevant regions. (煤炭就业的减少导致了更广泛的溢出效应，抑制了相关地区的整体经济增长。)

“deaths of despair” hypothesis

declining coal production could lead to higher rates of opioid use and mortality.

煤炭产量下降可能导致阿片类药物使用率和死亡率上升

Figure 8: Employment Level Change In the United States



*Data Source: Quarterly Census of Employment and Wages (QCEW)  
Index shows the employment level relative to year 2000.*

阿巴拉契亚地区的就业趋势，有无煤炭生产和美国其他地区：  
2010年后，全国就业率呈上升趋势，除了阿巴拉契亚那些不再生产（或从未生产）煤炭的县。

## Conceptual Framework

- Opinions 2

According to the same documentary by PBS, the Appalachian region :

**doctors** often prescribe more opioid than patients actually need

**Patients** (no matter real or not) can sell their exceeded prescription to addicts.

This increases **the prevalence of opioids in the illegal market**

**Former coal miners no longer need** to take opioid painkillers to stay in their position

The **prevalence of opioid** in the local community is going to decrease

lead to **less opioid death**.

These results combined should induce a **positive relationship between coal mining activity and opioid death.**

## IV. Empirical Methods

## 1. Baseline Model

a simple fixed-effect model

$$(1) \quad y_{it} = \beta_0 + \beta_1 S_{it} + \beta_2 S_{it-1} + \cdots + A X_{it} + \delta_t + \lambda_i + \theta_{st} + \varepsilon_{it}$$

$y_{it}$ 是县*i*在*t*年阿片类药物死亡率（每10万居民的死亡人数），

$S_{it}$ 是煤炭工人占当地全部就业人数的比例——表明煤矿开采在当地经济中起到很重要的作用

$X_{it}$ 是协变量的向量组，

$\delta_t$ 是时间固定效应，

$\lambda_i$ 是县固定效应，

$\theta_{st}$ 是州-年固定效应——将处方药监测计划（PDMP）和医疗补助等政策对经济状况的影响纳入其中  
将县失业率和家庭收入中位数作为协变量，解释当地经济状况，人口密度作为城镇化的代理变量。

加入县人口统计学变量，性别、年龄分布和受教育程度。

单个煤矿规模的变化和县本身规模的变化

加入就业比例滞后项——就业模式改变引起的阿片类药物死亡率

双向因果关系产生内生性——疼痛和阿片类药物使用对当地就业的影响。这表明由于误差项和煤矿  
就业比率之间的相关性，OLS估计可能存在偏差。使用IV方法解决。

## 2. Subgroup Analysis

the heterogeneous effects by *gender*

**Men to be more sensitive** to changes in coal mining activity than female death rates.

(男性阿片类药物死亡率对煤矿开采活动的变化比女性死亡率更敏感)

**Indirect effects** on female death rates

the heterogeneous relationships across different *age groups*

differential impacts between underground coal mining and surface mining.

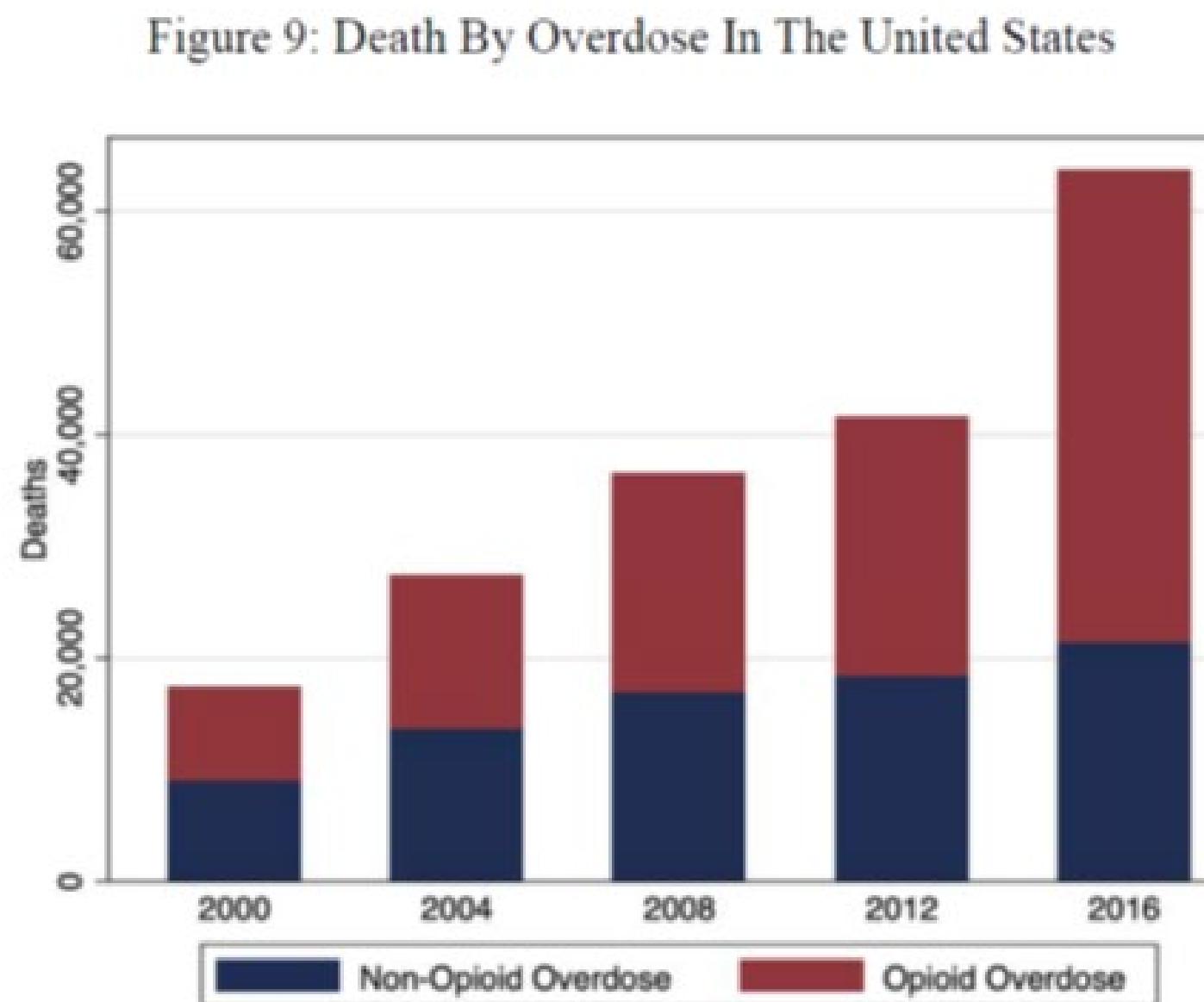
underground coal mining should have a stronger relationship with opioid death than surface coal mining.(地下煤矿开采与阿片类物质死亡的关系应该比露天煤矿强)

## V. Data

## 1. Mortality Data

All County Micro data compiled by the National Center for Health Statistics from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program based on data reported on death certificates for U.S. (由国家卫生统计中心根据57个生命统计管辖区通过生命统计合作计划提供的数据, 根据**美国居民死亡证书**上报告的数据编制的所有县微观数据)

on the restricted data: 预扣数据问题——漏报

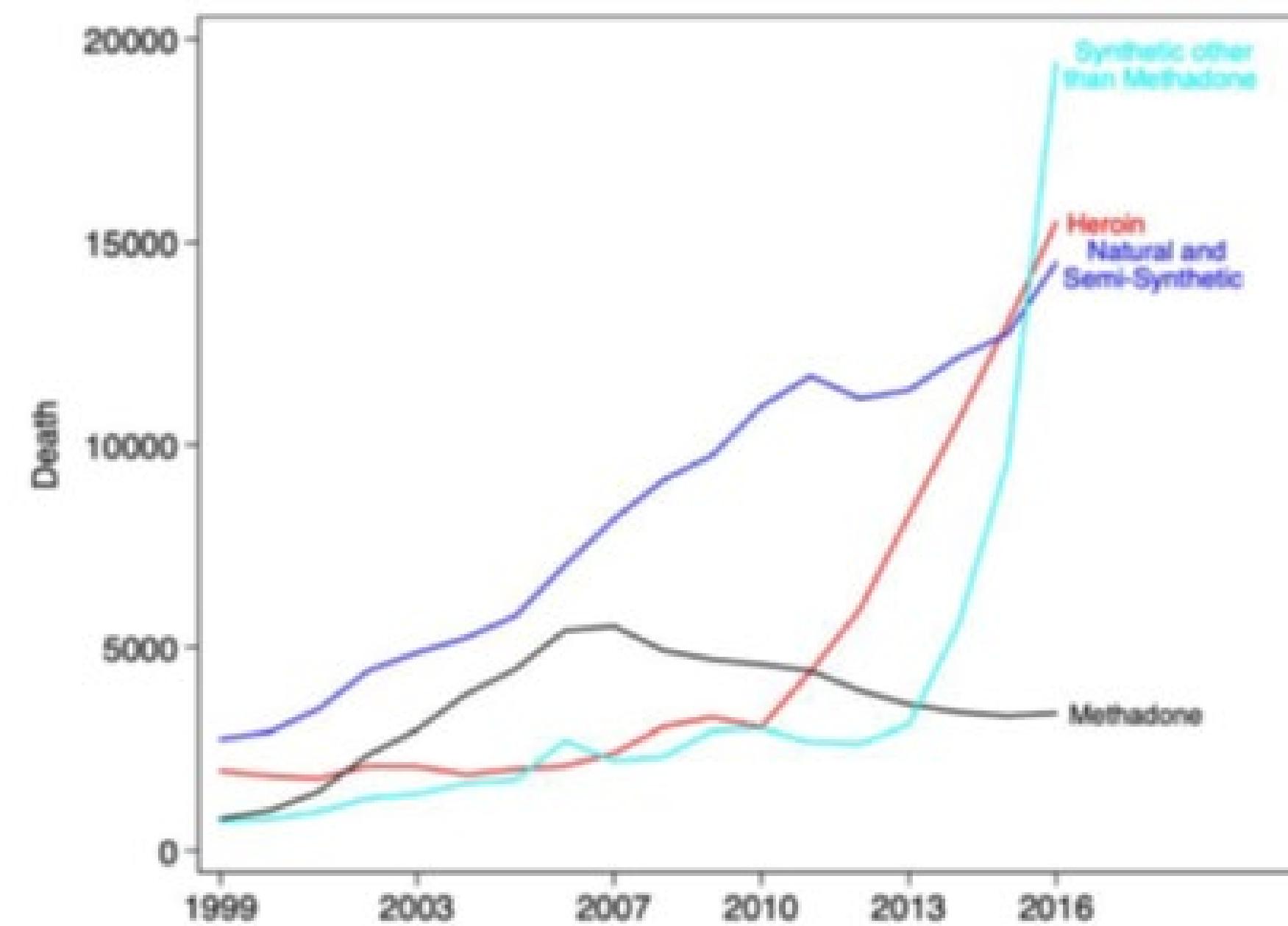


基本的人口统计信息  
一个潜在的死亡原因 (UCOD)  
多达20个多重死亡原因 (MCOD)  
公众使用的死亡率 (WONDER)

the increase in deaths due to overdoses over this period and the sharp increase in the proportion due to opioids.  
(因过量用药而死亡的人数增加, 因阿片类药物而死亡的比例急剧增加。)

## 1. Mortality Data

Figure 10: Drug Overdose Death, by Opioid Category



阿片类药物死亡人数有两次剧增：

一次是2010年以来海洛因导致的；

另一次是2013年以来除美沙酮以外的合成阿片类药物。

过去十年来，自然和半合成类阿片的死亡率一直在上升。

Data Source: CDC Mortality data.

Death Code: Any opioid (T40.0-T40.4, T40.6), heroin (T40.1), natural and semisynthetic opioids (T40.2), methadone (T40.3), and synthetic opioids other than methadone (T40.4).

## 1. Mortality Data

Table 1: Summary Statistics of Opioid Death by Gender

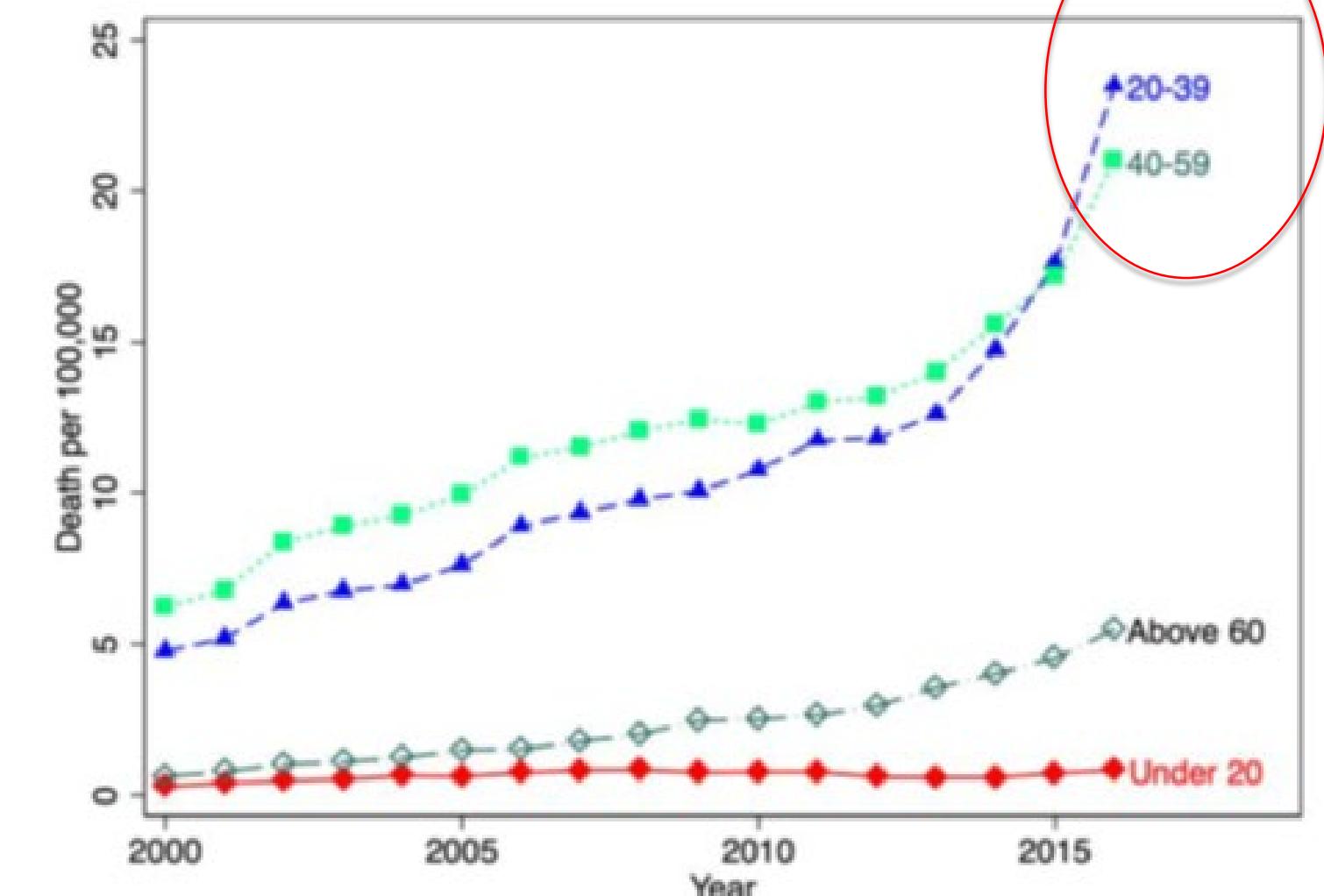
Year	Total		Male		Female	
	Number	Deaths per 100,000	Number	Deaths per 100,000	Number	Deaths per 100,000
2000	8342	1.60	6092	2.39	2250	0.85
2001	9420	1.77	6677	2.56	2743	1.01
2002	11842	2.19	8103	3.05	3739	1.36
2003	12938	2.33	8801	3.24	4137	1.47
2004	13756	2.44	9113	3.30	4643	1.62
2005	14918	2.65	9757	3.53	5161	1.80
2006	17545	3.02	11600	4.06	5945	2.01
2007	18516	3.15	11935	4.13	6581	2.20
2008	19580	3.30	12761	4.37	6819	2.26
2009	20421	3.41	13134	4.46	7287	2.39
2010	21086	3.48	13355	4.49	7731	2.51
2011	22782	3.73	14459	4.81	8323	2.68
2012	23166	3.77	14734	4.87	8432	2.70
2013	25051	4.04	15997	5.24	9054	2.87
2014	28647	4.57	18420	5.98	10227	3.21
2015	33089	5.24	21671	6.97	11418	3.56
2016	42249	6.63	28498	9.09	13751	4.25

Data Source: Center of Disease Control (CDC) Mortality data.

Deaths per 100,000: average county opioid death rate weighted by total population.

性别分类:阿片类药物的死亡人数和死亡率，并说明男性的死亡率高于女性。然而，女性的死亡率一直以比男性更快的速度增长。

Figure 11: Opioid Overdose Death Rate, by Age Group



Data Source: CDC Mortality data.

Death Code: Any opioid (T40.0-T40.4, T40.6), heroin (T40.1), natural and semisynthetic opioids (T40.2), methadone (T40.3), and synthetic opioids other than methadone (T40.4).

按年龄组划分的阿片类药物死亡率：显示了自2010年以来20至59岁年龄段成年人的死亡率迅速上升。

## 2. Coal Production Data

2000-2016年的单一煤矿生产和就业数据来自能源信息管理局 (EIA)

the Appalachian region covers between 80 and 90 percent of the producing coal mines in the United States for any given year.  
(阿巴拉契亚地区覆盖了美国任何一年80%到90%的生产煤矿。)

Production from surface mines is nearly double that of underground mines despite their hiring fewer workers.

露天矿的产量几乎是地下矿的两倍，尽管他们雇佣的工人更少。

Table 2: Output and Employment by Mine Type

Year	Total		Surface		Underground	
	Output	Employees	Output	Employees	Output	Employees
2001	1125.9	70.4	745.3	29.7	380.6	40.7
2002	1093.3	68.8	735.9	29.9	357.4	38.9
2003	1070.8	64.8	718.0	28.3	352.8	36.4
2004	1111.1	67.5	743.5	29.3	367.6	38.2
2005	1130.8	72.6	762.2	31.0	368.6	41.5
2006	1162.0	76.0	803.0	32.7	359.0	43.3
2007	1145.5	74.3	793.7	31.6	351.8	42.7
2008	1170.4	80.3	813.3	34.8	357.1	45.5
2009	1072.2	81.2	740.2	35.0	332.1	46.2
2010	1082.5	79.6	745.4	33.1	337.2	46.5
2011	1094.0	84.9	748.4	34.6	345.6	50.3
2012	1015.1	83.3	672.7	32.9	342.4	50.4
2013	982.9	74.6	641.2	28.7	341.7	45.9
2014	998.4	69.6	643.7	26.6	354.7	43.0
2015	895.6	61.3	588.7	24.2	306.8	37.1
2016	727.5	47.9	475.4	20.3	252.1	27.6

Data Source: EIA-7A.  
Output is in million short tons; Employees is in thousand people.

样本期间地表和地下矿山的产量和就业情况。

## 3. Other Data Sources

美国社区调查 (ACS) 中的家庭平均收入和受教育程度的县级数据

人口普查局的人口数据和劳工统计局(BLS)的就业数据。

Coal and non-coal producing counties.

The mean opioid death rate in coal-producing counties is **nearly twice** that of non-coal-producing counties.

Coal producing counties have a higher unemployment rate, lower population density, on average.

Educational attainment rates are slightly lower as well.

我们把县分为产煤县和非产煤县。

产煤县阿片类药物的平均死亡率几乎是非产煤县的两倍。

产煤县平均失业率较高，人口密度较低。受教育程度也略低。

Table 3: Summary Statistics

	National	Coal Producing	Non-Coal Producing
Death Rate(Opioid) per 100k	6.903 (9.283)	12.607 (15.882)	6.540 (8.570)
Death Rate(Any) per 100k	12.590 (12.289)	20.820 (17.960)	12.068 (11.643)
Share Of Coal Miners	0.003 (0.020)	0.047 (0.066)	0.000 (0.000)
Output(Million Tons)	0.328 (6.729)	5.493 (27.020)	0.000 (0.000)
Unemployment Rate	6.820 (2.956)	7.530 (2.694)	6.775 (2.966)
Median Household Income	44.786 (11.886)	40.474 (9.621)	45.059 (11.964)
Population Density	262.135 (1755.237)	98.517 (159.247)	272.527 (1809.180)
Male Population Ratio	0.500 (0.022)	0.499 (0.016)	0.500 (0.023)
Age Group 20-39 Ratio	0.237 (0.044)	0.241 (0.033)	0.237 (0.044)
Age Group 40-59 Ratio	0.277 (0.027)	0.282 (0.022)	0.277 (0.027)
High School Diploma Rate	83.547 (7.364)	81.359 (8.204)	83.686 (7.285)
Bachelor's Degree Rate	19.336 (8.762)	15.798 (7.263)	19.561 (8.801)
Observations	34509	2061	32448

Year Range: 2006-2016. Standard Errors in Parentheses. Coal mining counties are counties that produced coal in any year of our sample

## VI. Results

Table 4: OLS Results by Gender Groups

	Opioid Death Rate		
	Whole Population	Male	Female
<b>Share of Coal Miners</b>			
Effect	51.886*** (16.608)	43.905* (25.988)	59.357*** (17.667)
S.E.	0.427	0.299	0.801
IQR Impact	0.192	0.129	0.296
Elasticity	3	3	3
Lags			
<b>Share of Underground Miners</b>			
Effect	73.476*** (25.416)	89.600** (43.784)	54.663* (29.621)
S.E.	0.212	0.214	0.258
IQR Impact	0.115	0.111	0.115
Elasticity	3	3	3
Lags			
<b>Share of Surface Miners</b>			
Effect	55.490** (23.435)	34.912 (36.628)	76.155*** (22.174)
S.E.	0.233	0.121	0.525
IQR Impact	0.119	0.06	0.22
Elasticity	3	3	3
Lags			

Year Range: 2006-2016.

Includes year fixed effect, county fixed effect, state-by-year fixed effect.

Effect is the linear combination of all lagged terms.

Standard errors clustered at county level in parentheses, \*\*\* $p<0.01$ , \*\* $p<0.05$ , \* $p<0.1$ .

the interquartile range impact  
(IQR Impact)

$$(2) \text{ } IQR \text{ Impact} = \frac{(\sum_{s=0}^3 \beta_s) \times IQR}{y_{median}}$$

采矿活动的劳动比例从25分位数变到75分位数时各县死亡率中位数变化 $y_{median}$ 的百分比。

## The top panel

results focusing on the share of **all** coal miners in the labor force.

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Effect is the linear combination of all lagged terms.

Standard errors clustered at county level in parentheses, \*\*\* $p<0.01$ , \*\* $p<0.05$ , \* $p<0.1$ .

1% increase in the share of coal miners is associated with an increase in the mortality rate of 0.52 per 100,000. 显著

elasticity of 0.192:

comparable between men and women:  
women — elasticity of the response is higher;  
more precisely

Moving from the 25th to the 75th percentile in labor force share increases the opioid mortality rate by 1/3 for men and 4/5 for women, 2/5 for the population as a whole.

劳动力比例的25%上升到75%，男性阿片类药物死亡率增加了1/3，女性增加了4/5，或者说整个人口大约增加了2/5。

Table 4: OLS Results by Gender Groups

	Opioid Death Rate		
	Whole Population	Male	Female
<b>Share of Coal Miners</b>			
Effect	51.886*** (16.608)	43.905* (25.988)	59.357*** (17.667)
S.E.	0.427	0.299	0.801
IQR Impact	0.192	0.129	0.296
Elasticity	3	3	3
Lags			
<b>Share of Underground Miners</b>			
Effect	73.476*** (25.416)	89.600** (43.784)	54.663* (29.621)
S.E.	0.212	0.214	0.258
IQR Impact	0.115	0.111	0.115
Elasticity	3	3	3
Lags			
<b>Share of Surface Miners</b>			
Effect	55.490** (23.435)	34.912 (36.628)	76.155*** (22.174)
S.E.	0.233	0.121	0.525
IQR Impact	0.119	0.06	0.22
Elasticity	3	3	3
Lags			

Year Range: 2006-2016.

Includes year fixed effect, county fixed effect, state-by-year fixed effect.

Effect is the linear combination of all lagged terms.

Standard errors clustered at county level in parentheses, \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ .

## The next panel

effect is now larger

The elasticities and IQR impacts are smaller

comparable between men and women, 显著

That increased mining activity increases the **female** opioid death rate suggests an **indirect impact** of coal mining on mortality given the very **small number of women coal miners**.

Table 5: OLS Results by Age Groups

	Opioid Death Rate			
	Under 20	20-39	40-59	Above 60
<b>Share of Coal Miners</b>				
Effect	5.993	93.515*	73.714**	18.847
S.E.	(5.431)	(50.670)	(35.377)	(18.358)
IQR Impact	.	0.460	0.415	.
Elasticity	0.308	0.190	0.156	0.326
Lags	3	3	3	3
<b>Share of Underground Miners</b>				
Effect	0.463	277.19***	5.795	17.27
S.E.	(6.809)	(91.307)	(62.969)	(27.598)
IQR Impact	.	0.477	0.011	.
Elasticity	0.01	0.237	0.005	0.126
Lags	3	3	3	3
<b>Share of Surface Miners</b>				
Effect	11.472	52.941	109.024**	21.638
S.E.	(8.044)	(63.441)	(51.011)	(25.546)
IQR Impact	.	0.133	0.313	.
Elasticity	0.342	0.062	0.134	0.217
Lags	3	3	3	3

Year Range: 2006-2016.

Includes year fixed effect, county fixed effect, state-by-year fixed effect.

Effect is the linear combination of all lagged terms.

Standard errors clustered at county level in parentheses, \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

20-39岁人口的影响是四者中最大

## VII. Further Results

## 1. Instrumental Variable Approach with a Bartik Instrument

当地的阿片类药物流行可能对该地区煤矿的劳动力就业产生负面影响。

construct the Bartik-style variable for coal employment as:

$$B_{jt} = \frac{1}{P_{jt}} \sum_k \left( L_{jkt_0} \times \frac{\sum_{i \in \{counties \setminus j\}} L_{ikt}}{\sum_{i \in \{counties \setminus j\}} L_{ikt_0}} \right)$$

$B_{jt}$ 是j县, t年和煤炭类型编码k的工具变量 (地面或地下)。

$L_{kt}$ 是t年煤炭类型编码k的国家就业水平,

$P_{jt}$ 是j县, t年的人口数,

$L_{jkt_0}$ 是j县煤炭类型k在基年 (2006)  $t_0$ 年的煤炭雇佣水平。

地方就业变化与国家就业变化相关, 与地方冲击无关。这假设全国煤矿业就业水平不受阿片类药物死亡率的局部冲击影响。

Table 6: IV Results with Bartik Instrument, by Gender Groups

	Opioid Death Rate		
	Whole Population	Male	Female
<b>Share of Coal Miners</b>			
Effect	113.153*** (22.765)	125.802** (36.625)	103.839* (62.059)
S.E.			
IQR Impact	0.931	0.857	1.401
Elasticity	0.420	0.371	0.517
Lags	3	3	3
<b>Share of Underground Miners</b>			
Effect	260.813*** (51.391)	298.114*** (78.990)	230.268 (140.589)
S.E.			
IQR Impact	0.751	0.711	1.088
Elasticity	0.407	0.370	0.483
Lags	3	3	3
<b>Share of Surface Miners</b>			
Effect	199.517*** (40.822)	216.698*** (67.604)	188.765* (110.546)
S.E.			
IQR Impact	0.838	0.753	1.301
Elasticity	0.429	0.37	0.545
Lags	3	3	3

Year Range: 2006-2016.

Includes year fixed effect, county fixed effect, state-by-year fixed effect.

Effect is the linear combination of all lagged terms.

Standard Errors are obtained by bootstrap in parentheses, \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

the impact is now larger

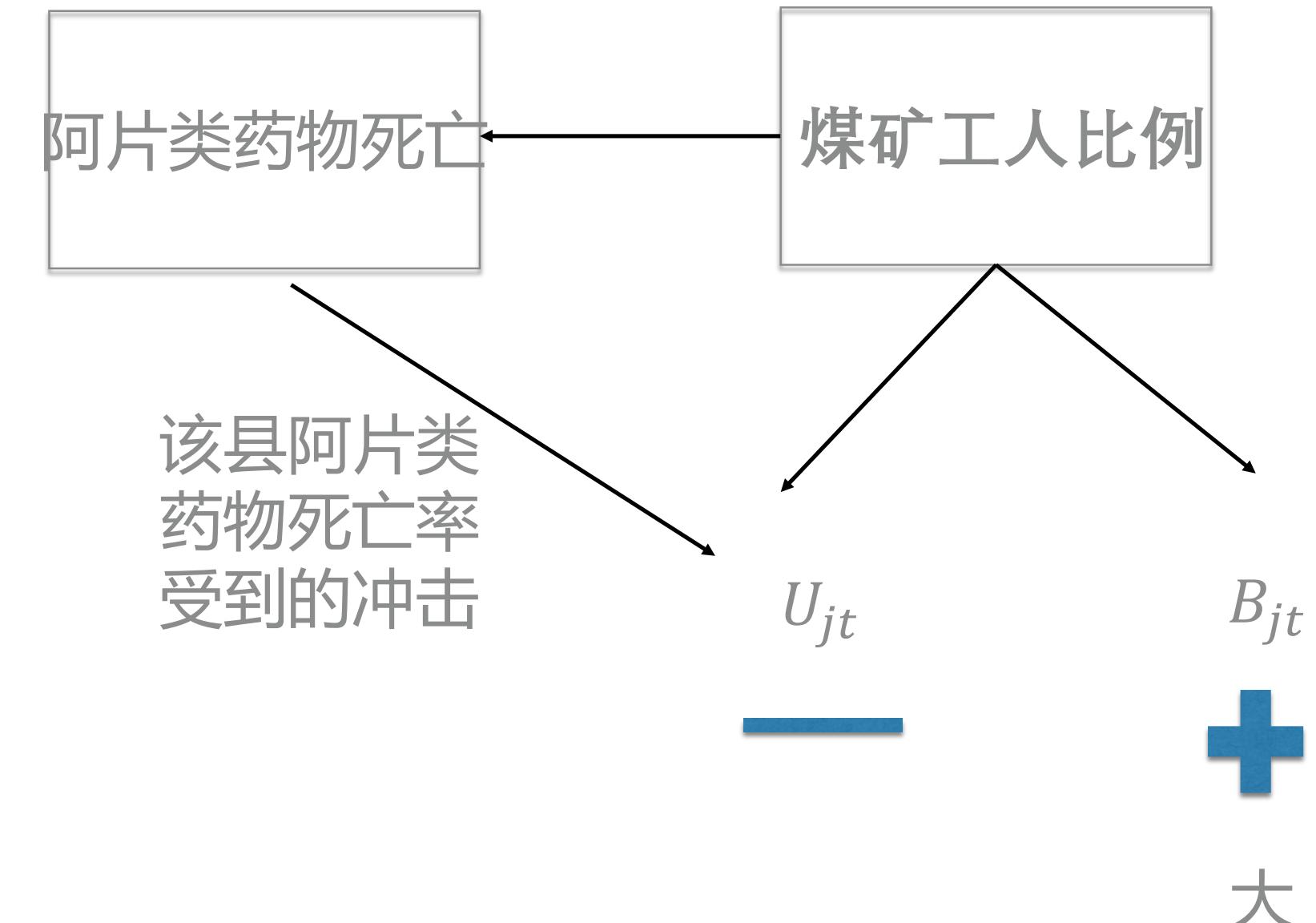


Table 7: IV Results with Bartik Instrument, by Age Groups

	Opioid Death Rate			
	Under 20	20-39	40-59	Above 60
<b>Share of Coal Miners</b>				
Effect	-37.359***	82.255	339.212***	62.435*
S.E.	(13.372)	(83.743)	(120.588)	(37.270)
IQR Impact	.	0.405	1.910	.
Elasticity	-1.920	0.167	0.719	1.080
Lags	3	3	3	3
<b>Share of Underground Miners</b>				
Effect	-79.780***	193.289	781.863***	144.297*
S.E.	(30.793)	(182.159)	(275.736)	(81.676)
IQR Impact	.	0.333	1.541	.
Elasticity	-1.726	0.165	0.698	1.05
Lags	3	3	3	3
<b>Share of Surface Miners</b>				
Effect	-69.558***	145.289	595.799***	109.337
S.E.	(23.770)	(153.857)	(213.968)	(68.320)
IQR Impact	.	0.365	1.713	.
Elasticity	-2.071	0.171	0.732	1.095
Lags	3	3	3	3

Year Range: 2006-2016.

Includes year fixed effect, county fixed effect, state-by-year fixed effect.

Effect is the linear combination of all lagged terms.

Standard Errors are obtained by bootstrap in parentheses, \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

除20岁以下年龄组外，估计的影响一致较大

## 2. Underlying Mechanism

Table 8: Opioid Prescription Rates

	Opioid Prescription Rate	
	OLS	IV
<b>Share of Coal Miners</b>		
Effect	66.363	132.069
S.E.	(72.562)	(94.346)
IQR Impact	0.039	0.077
Elasticity	0.026	0.052
Lags	3	3
<b>Share of Underground Miners</b>		
Effect	222.919*	273.461
S.E.	(122.590)	(204.869)
IQR Impact	0.046	0.056
Elasticity	0.037	0.046
Lags	3	3
<b>Share of Surface Miners</b>		
Effect	9.433	253.447
S.E.	(83.191)	(175.554)
IQR Impact	0.003	0.076
Elasticity	0.002	0.058
Lags	3	3

Year Range: 2006-2016.

Includes year fixed effect, county fixed effect, state-by-year fixed effect.

Effect is the linear combination of all lagged terms.

For OLS, standard errors clustered at county level in parentheses.

For IV, standard errors obtained by bootstrap in parentheses \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

The estimated coefficients, however, are not statistically significant for the most part.

While suggestive, we would not want to argue that we have found a smoking gun mechanism. (虽然有暗示意义, 但我们不想争辩说, 我们已经找到了一种冒烟的枪支机制。)

## 3. Contrasting Coal Mining with Retailing

Table 9: Retailing Sector Regressions, by Gender Groups

	Opioid Death Rate		
	Whole Population	Male	Female
Share of Retail			
Effect	-5.146	-16.067**	6.541
S.E.	(5.650)	(7.301)	(7.891)
IQR Impact	-0.025	-0.066	0.053
Elasticity	-0.049	-0.122	0.084
Lags	3	3	3

Year Range: 2006-2016.

Includes year fixed effect, county fixed effect, state-by-year fixed effect.

Effect is the linear combination of all lagged terms.

Standard errors clustered at county level in parentheses, \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

零售业中的劳动力份额替换煤矿开采中的劳动力份额

预计零售劳动力份额对阿片类药物死亡率的边际影响较小

因为它的工资水平相似，但体力劳动要求较低。

负相关表明潜在的“绝望死亡”与较低的经济活动和较高的阿片类药物死亡率有关。

Table 10: Retailing Sector Regressions, by Age Groups

	Opioid Death Rate			
	Under 20	20-39	40-59	Above 60
Share of Retail				
Effect	-4.462	-22.854*	-1.273	7.644
S.E.	(3.630)	(13.607)	(12.405)	(8.658)
IQR Impact	.	-0.068	-0.004	.
Elasticity	-0.590	-0.119	-0.007	0.340
Lags	3	3	3	3

Year Range: 2006-2016.

Includes year fixed effect, county fixed effect, state-by-year fixed effect.

Effect is the linear combination of all lagged terms.

Standard errors clustered at county level in parentheses, \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

## VIII. Conclusion

The results suggest that a higher share of coal miners among the local total workforce is associated with a higher opioid death rate.

(当地全部劳动力中的煤矿工人占比越大，阿片类药物死亡率越高。)

This conclusion is the opposite of what mainstream media would claim.

(结论与主流媒体的说法截然相反)

Bartik-style instrumental variable to control for potential endogeneity between employment and opioid abuse.

(工具变量控制就业和阿片类药物滥用的潜在内生性)

Estimates from the IV regressions are larger and more statistically significant than those of OLS for men.

(IV回归的估计值比OLS对男性回归的估计值更大更显著)

increasing coal mining activity——more workplace injuries——higher opioid prescription rates—— a consequent greater prevalence of opioids in the community

由于数据的限制，本研究**没有进一步探讨煤矿开采活动和阿片类药物死亡率之间的正相关关系背后的机制**。  
如果可以获得个人水平的数据，未来可以进行更彻底的分析。

推测下岗煤矿工人已经被其他行业吸收。

看看煤炭替代产业较多的地区是否在煤炭开采活动和阿片类药物死亡率之间表现出不同关系将会很有趣。