# The Opioid Epidemic: Causes and Consequences

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# Motivation: The Opioid Epidemic

Overdose deaths involving opioids have increased dramatically in the US

- Since 1999, more than 250,000 have died due to poisoning from prescription opioids (CDC).
- The epidemic has also been accompanied by:
  - Stagnation in labor force participation.
  - Increase in disability claims.
  - Worsening of birth outcomes.
  - Record numbers of children living in foster care.

# Motivation: What caused the epidemic & what were the effects?

- Deteriorating socioeconomic conditions could have caused the increase in demand for opioids and the subsequent negative outcomes.
- Supply-side factors, such as the dramatic increase in opioid access, changes in physician prescribing attitudes, and the aggressive marketing of prescription opioids.
- The variation in the level of prescription opioids across geographies and over time is not random.
  - Incidence of pain.
  - Access to healthcare, number of physicians per capita.

# This paper

Empirical approach

- Propose a novel instrumental variable based on Purdue Pharma's marketing strategy.
  - Recently unsealed court records from state litigation against Purdue Pharma.
- Exploit variation in the promotion of prescription opioids initially targeted to the cancer market.

Identify the **role of supply**-side forces on the origins of the epidemic.

Estimate the **causal effect** of the opioid epidemic on a host of important variables.

- Drug-related mortality.
- Labor force participation (LFP), Disability, SNAP & crime.
- Birth outcomes & fertility.

Data

- National Vital Statistics System: micro-level data with geographic identifiers.
- ARCOS: data on controlled substance transactions collected by the DEA.
- FBI Uniform Crime Reporting, SSA & BLS.

# This paper: Results

Moving from the 25th to the 75th percentile in the distribution of prescription opioids:

- An increase of 5.02 doses per capita or the median increase between 1999 and 2010.
- Increases deaths from prescription opioids by 89% and deaths from all opioids by 39% .
  - This corresponds to over 200,000 deaths.
- No effect on labor market outcomes: labor force participation or employment rates.
  - Small increase in LFP in the first wave of the epidemic.
- Increases claims from SNAP (57%), disability (SSI 47% & SSDI 76%), and crime (60%).
- Decreases pregnancy duration (0.24 weeks), birth weight (0.7%), and health at birth but has no effect on infant mortality.
- Increase in fertility rates (9%), driven by women 25-29 years old.
- Decrease in mortality for the elderly (14%).

# Contribution to the Literature

1. Origins of the Opioid Epidemic
   - Demand: Case and Deaton (2015, 2017)
   - Supply: Alpert et al. (2019); Powell et al. (2020); Fernandez and Zejcirovic (2019); Finklestein et al. (2019); Currie and Schnell (2018); Eichmeyer and Zhang (2020)

   New evidence linking OxyContin's marketing to the rise in supply & mortality from opioids.

2. Effects of the Opioid Epidemic
   - Drug Mortality: Powell et al. (2015) ; Evans et al. (2018); Alpert et al. (2018); Eichmeyer and Zhang (2020).
   - Employment: Currie et al (2018); Harris et al (2019), Alipantris et al. (2019); Beheshto et al. (2019).
   - Disability, and Crime: Park and Powell (2020); Dave et al. (2020).
   - Maternal, birth and children's outcomes: Lynch et al. (2018); Wolf et al. (2018); Ziedan and Kaestner (2020); Buckles et al. (2020).

   Direct causal evidence on a comprehensive group of outcomes.

# Agenda

1. Context: The Opioid Epidemic
2. OxyContin & the Marketing of Prescription Opioids
3. Data
4. Empirical Strategy
5. Results
6. Policy Implications & Conclusions

# Context: The Opioid Epidemic I

- "Opioids" refers to a class of a large number of drugs, both natural and synthetic.
  - Natural: heroine and morphine.
  - Synthetic: oxycodone and hydrocodone.
  - All pharmacologically similar.
- Opioids are highly addictive, with rapid progression to physiological dependence with tolerance and withdrawal.
- Physical dependence can occur even at prescribed doses & within a short period of time (Hah et al., 2017; Sharma et al., 2017).
  - Withdrawal symptoms include generalized pain, chills, cramps, diarrhea, dilated pupils, restlessness, anxiety, nausea, vomiting, insomnia, and intense cravings.

# Context: The Opioid Epidemic II

- Prescription opioids are mostly used to treat moderate to severe pain.
- Opioid prescriptions peaked at 81.3 prescriptions per 100 persons in 2012 (CDC).
- In 2017, 35% of adults used opioid painkillers (NSDUH-2017).
- Between 4 and 5% of adults in the US misuse prescription opioids.
- Legitimate prescriptions of opioids have been linked to:
  - Long-term opioid dependency from a prescription in the ER (Barnett et al., 2017).
  - Increased probability of opioid overdose by a family member (Khan et al., 2019).
  - Heroin and other illegal drug use (APA, 2017).

Who uses and abuses opioids?

# Rapid growth of oxycodone prescriptions and prescription opioid deaths

*Notes:* Authors' computation. Data on oxycodone, hydrocodone, morphine and other prescription opioids come from ARCOS and is expressed in morphine-equivalent doses. Deaths from prescription opioids are constructed from NVSS data.

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# The opioid crisis & the success of OxyContin

*OxyContin*

Prescription opioid pain reliever from Purdue Pharma. Active ingredient: oxycodone.

- Technological innovation
  - Single-agent opioid: No ceiling allows for high opioid concentration.
  - Extended-release formulation: Relieves pain for up to 12 hours.
  - Mostly prescribed in 20 mg and 40 mg tablets.
- Sales and marketing strategy
  - Sales representatives making around 100k a year, and up to 250k.
  - Pushed a message of low addiction rate of opioids and of an epidemic of untreated pain.

# Unsealed Court Records: Kentucky vs Purdue: The Marketing of Prescription Opioids

| Background | Setting the stage | Phase 1 | Phase 2 |
|---|---|---|---|
| • Opioid addiction stigma – patients & physicians<br>• Opioids (morphine) used only for terminal cancer<br>• Untreated pain<br>• Low physician prescription oversight | • MS Contin: Gold standard to treat cancer pain<br>• MS Contin expected to face generic competition | | |

Certainty about OxyContin entering the market 1994

Launch of OxyContin 1996

Expansion phase Post-1997

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## Phase 1

**Objective:**

Establish the use of OxyContin for moderate & chronic pain

**Two main challenges**

1. **Stigma**
2. **Paperwork**

## Phase 2

Certainty about OxyContin entering the market
1994

Launch of OxyContin
1996

Expansion phase
Post-1997

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Certainty about OxyContin entering the market 1994 → Launch of OxyContin 1996 → Expansion phase Post-1997

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2. **Paperwork**

Target Promotion to:

- Cancer patients & physicians
- Pharmacies already prescribing narcotics
- Non-triplicate states

## Phase 2

Certainty about OxyContin entering the market
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1. **Stigma**
2. **Paperwork**

## Phase 2

- Expand promotion to Primary care physicians & family doctors
- Focus disproportionally on top prescribers
- Produce clinical trials for the use of OxyContin in non-malignant pain

Certainty about OxyContin entering the market 1994

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Expansion phase Post-1997

# Unsealed Court Records: Kentucky vs Purdue: Our Identification Strategy

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- Opioid addiction stigma – patients & physicians
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# Unsealed Court Records: Kentucky vs Purdue

- *"OxyContin Tablets will be targeted at the cancer pain Market."*
  OxyContin Team Meeting, April 1994.
- *"OxyContin primary market positioning will be for cancer pain."*
  OxyContin Launch Team Meeting, March 1995.
- *"At the time of launch, OxyContin will be marketed for cancer pain."* OxyContin Launch Plan, September 1996.
- *"The use of OxyContin in Cancer Patients, initiated by their Oncologists and then referred back to FPs/GPs/IMs, will result in a comfort that will enable the expansion of use in chronic non-malignant pain patients also seen by the family practice specialists."* OxyContin Launch Plan, September 1996.

# Unsealed Court Records: Kentucky vs Purdue

Marketing considerations for this decision:

- OxyContin Focus Group (1995)

*"There is not the same level of enthusiasm toward this drug for use in non-cancer pain as we identified in cancer pain."*

Logistic considerations for this decision:

- Cancer patients already have access to pharmacies that prescribe Schedule II drugs
  - By the time of the launch of OxyContin, only 40% of pharmacies had the paperwork to sell Schedule II drugs.

*"Pharmacists are generally reluctant to stock Class II opioids."*

*"Initial targets will be the 25,000 stores who stock MS Contin."*

# Identification: Cancer & Opioid Prescriptions

- Areas with higher cancer incidence received disproportionate marketing of opioids.
- We exploit this as a source of exogenous variation in the supply of prescription opioids.
- Purdue's later strategy to target high prescribers creates path dependency.
- This allows for the identification of
  1. The role of supply in the crisis.
  2. The causal effect of the opioid epidemic on a broad range of outcomes.

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# Data

- ARCOS: transactions of controlled substances by active ingredient (e.g. oxycodone).
- National Vital Statistics System with county identifiers.
  - Opioid-related deaths, cancer mortality rate, birth and maternal outcomes.
- Local Area Unemployment Statistics (BLS): labor force participation and employment.
- Social Security Administration Reports: SSI and SSDI beneficiaries counts.
- Food and Nutrition Service Reports: beneficiaries counts of SNAP.
- Uniform Crime Reports (FBI): reported crimes for all, violent and property crimes.
- Our final dataset: 11,800 observations, 590 commuting zones (+25,000 population).

# Descriptive Statistics

| | Mean | Median | SD | Min | Max |
|---|---|---|---|---|---|
| **Opioid Prescriptions: Doses per capita** | | | | | |
| All opioids | 6.42 | 5.48 | 4.32 | 0.00 | 57.65 |
| Oxycodone | 3.15 | 2.52 | 2.60 | 0.00 | 51.31 |
| **Cancer Mortality per 1,000** | | | | | |
| Cancer mortality rate 1994-1996 | 2.52 | 2.53 | 0.58 | 0.11 | 6.04 |
| Cancer mortality rate | 2.48 | 2.49 | 0.55 | 0.59 | 4.75 |
| **Direct outcomes: Mortality per 1,000** | | | | | |
| Prescription opioids | 0.04 | 0.03 | 0.05 | 0.00 | 1.06 |
| Any opioids | 0.07 | 0.05 | 0.07 | 0.00 | 1.22 |

Opioids prescription map Cancer mortality map Opioids mortality map

# Descriptive Statistics

| | Mean | Median | SD | Min | Max |
|---|---|---|---|---|---|
| Labor force participation | 0.48 | 0.49 | 0.06 | 0.02 | 1.00 |
| Employment | 0.94 | 0.94 | 0.02 | 0.73 | 0.99 |
| Share SSI | 0.04 | 0.03 | 0.02 | 0.00 | 0.30 |
| Share SSDI | 0.05 | 0.04 | 0.02 | 0.01 | 0.16 |
| Share SNAP | 0.12 | 0.11 | 0.06 | 0.00 | 0.57 |
| Total crime rate | 1,574.51 | 1,383.37 | 1,372.12 | 0.00 | 6,849.93 |
| Violent crimes rate | 168.38 | 122.09 | 174.31 | 0.00 | 1,249.73 |
| Infant MR (per 1,000 births) | 6.86 | 6.54 | 2.87 | 0.00 | 30.61 |
| Share low birth weight | 0.08 | 0.08 | 0.02 | 0.02 | 0.20 |
| Share preterm | 0.12 | 0.12 | 0.03 | 0.05 | 0.62 |
| APGAR score - all infants | 8.82 | 8.84 | 0.19 | 5.00 | 10.00 |
| Fertility rate | 0.08 | 0.08 | 0.01 | 0.04 | 0.19 |

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# Empirical Strategy: IV

- We exploit Purdue's initial cancer targeting for the promotion of opioids to
  1. Estimate the role of supply in the epidemic.
  2. Estimate the causal effects of the epidemic.

# Empirical Strategy: IV

(i) Does cancer MR in the mid-1990s predict growth in the supply of prescription opioids?
**Relevance**

(ii) What determines cancer MR in the mid-1990s, and is it related to our outcome variables?
**Exogeneity & Exclusion**

(iii) Is cancer MR in the mid-1990s predictive of future mortality from opioids?
**Reduce form**

(iv) Are other mid-1990s mortality rates predictive of future prescription opioid distribution?
**Placebo check**

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# In high-cancer czones oxycodone supply increased 3 times more than in low-cancer czones

Notes: This figure shows the evolution of oxycodone, hydrocodone, and morphine in the forth quartile (solid lines) and first quartile (dashed lines) of the cancer mortality rate distribution before the launch of OxyContin. Oxycodone and hydrocodone are measured in morphine-equivalent mg.

All prescription opioids With cancer trends

# Positive and strong relationship between 94-96 cancer MR and the change in opioids

| Dependent variable: Prescription opioids per capita | | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Cancer MR 94-96 | 0.960*** | 1.091*** | 1.061*** | 1.132*** | 1.078*** |
| *se* | [0.210] | [0.222] | [0.231] | [0.258] | [0.264] |
| *t-stat* | 4.571 | 4.914 | 4.593 | 4.388 | 4.083 |
| *Effective F-stat* | 20.894 | 24.147 | 21.096 | 19.254 | 16.630 |
| Effect size (%) | 56.92 | 64.69 | 62.91 | 67.12 | 63.92 |
| Controls | No | No | No | Yes | Yes |
| FE | No | State Year | State × Year | State Year | State × Year |
| Observations | 11,800 | 11,800 | 11,800 | 11,800 | 11,800 |
| Clusters | 590 | 590 | 590 | 590 | 590 |
| Adjusted $R^2$ | 0.019 | 0.524 | 0.559 | 0.533 | 0.564 |

Notes: Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years, share of Black, White, and Hispanic population, and share of female population. Effect size is computed as the predicted changes in doses of prescription opioids per capita from an increase in cancer mortality that would change a commuting zone in the 5th percentile of the cancer distribution to the 95th percentile. Standard errors are clustered at the CZ level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Leave out | Sample restrictions - size | Sample restrictions - time | Alternative dependent variables | Shift-share specification

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# Higher cancer MR areas are not on a differential trend for education, income, or health.

| Independent variable: Cancer MR 89-90 | | | |
|---|---|---|---|
| *Dependent variables:* | | *Dependent variables:* | |
| Income per capita | 19.42 | Labor force participation | -0.00153* |
| | [62.24] | | [0.000821] |
| Share with some college | 0.0063 | Employment rate | -0.000781 |
| | [0.00386] | | [0.000489] |
| Share with high school or less | 0.00257 | Share SNAP | -0.000529 |
| | [0.00420] | | [0.000840] |
| Share working in manufacturing | 0.0063 | Share SSDI | -0.000523 |
| | [0.00386] | | [0.000890] |
| Prescription opioids MR | -0.000795 | Share SSI | 0.000151 |
| | [0.000580] | | [0.000345] |
| Any opioids MR | -0.00101 | Total crime rate | 44.5 |
| | [0.000671] | | [28.63] |
| IMR | -0.0989 | Fertility rate | -0.641 |
| | [0.154] | | [0.490] |

Notes: Each coefficient corresponds to a separate regression in which the dependent variable is measured as the change with respect to 1989-1990. For prescription opioids, any opioids, labor market variables, crime, SNAP, and IMR, we run a panel regression; for other variables, where yearly data are not available, we run one cross-sectional regression. All regressions include control variables. In panel-level regressions, standard errors are clustered at the commuting-zone level; in cross-sectional regressions, standard errors are robust to heteroskedasticity. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

# Lagged cancer mortality (1989-1990) is unrelated to future opioid mortality

| Dependent var: | Prescription opioid MR | All opioid MR |
|---|---|---|
| | (1) | (2) |
| Cancer MR 89-90 | -0.000122 | -0.000208 |
| | [-0.16] | [-0.22] |
| Model | RF | RF |
| Observations | 3,540 | 3,540 |
| Clusters | 590 | 590 |
| Adj $R^2$ | 0.0650 | 0.1300 |

Notes: This table presents results of our reduced-form regression in an out-of-sample period, where we regress opioid-related mortality from 1991 to 1996 in lagged cancer mortality (1989-1990). * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

- The connection between cancer incidence and opioid mortality exists only as a result of the marketing of OxyContin

Robustness summary

# Empirical Strategy: IV

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**Placebo check**

# Marketing of prescription opioids had a positive effect on prescription opioid mortality

Notes: This figure shows the evolution of prescription opioid mortality by 1994-1996 cancer prevalence. The high-cancer mortality rate corresponds to the group of commuting zones in the fourth quartile of cancer mortality in 1994-1996, and low cancer corresponds to the first quartile. The vertical line at 1996 indicates the year OxyContin was launched.

All opioid mortality Reduced form results

# Empirical Strategy: IV

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# Alternative measures of mortality in 1994-1996 do not predict prescription opioid supply

| Dependent variable: | Prescriptions opioids per capita | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Cardiovascular disease 94-96 | 0.372 | | -2.023** | |
| | [0.611] | | [0.822] | |
| Transit accidents 94-96 | | 1.621 | | -0.991 |
| | | [1.546] | | [1.528] |
| Cancer 94-96 | | | 1.381*** | 0.954*** |
| | | | [0.347] | [0.243] |
| Model | FS | FS | FS | FS |
| Observations | 11,800 | 11,800 | 11,800 | 11,800 |
| Adjusted $R^2$ | 0.588 | 0.587 | 0.602 | 0.598 |
| Clusters | 590 | 590 | 590 | 590 |

Notes: Columns 1-2 report first-stage regression with alternative instrument. Columns 3-4 add our baseline instrument. All regressions include state times year fixed effects and a set of control variables: labor force participation, contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at the CZ level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Robustness summary

# Empirical Strategy: IV

- We estimate the causal effect of the supply of prescription opioids via the following equation:

$$\text{First Stage:} \quad \Delta\ Presc.\ Opioids_{ct} = \alpha_0 + \phi\ CancerMR_{ct_0} + \alpha\ \Delta\ X_{ct} + \gamma_{st} + \upsilon_{ct}$$

$$\text{Second Stage:} \quad \Delta\ y_{ct} = \tau_0 + \beta\ \Delta \widehat{Presc.\ Opioids}_{ct} + \tau\ \Delta\ X_{ct} + \lambda_{st} + \varepsilon_{ct}$$

- $\Delta$: long-change operator, i.e., $\Delta W_{ct} \equiv W_{ct} - W_{ct_0}$.
- $Presc.\ Opioids_{ct}$: doses of opioids per capita shipped to commuting zone $c$ in year $t$.
- $CancerMR_{ct_0}$: cancer mortality rate in commuting zone $c$ in 1994-1996 ($t_0$).
- $y_{ct}$: outcomes of interest, e.g., a measure of opioid-related mortality.
- $\Delta\ X_{ct}$: time-varying control variables (expressed in long-changes).
- $\gamma_{st}$ and $\lambda_{st}$: state times year fixed effects.

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# Results

(i) Direct effects: Opioid-related mortality

(ii) All-cause adult mortality

(iii) Labor market and social assistance benefits

(iv) Crime

(v) Birth and maternal outcomes

# Results

(i) Direct effects: Opioid-related mortality

(ii) All-cause adult mortality

(iii) Labor market and social assistance benefits

(iv) Crime

(v) Birth and maternal outcomes

# A 25th to 75th movement in the distribution of opioids increases prescription opioid mortality by 89%

| Dependent var: | Prescription opioids | | All opioids | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | 0.00374*** | 0.00679*** | 0.00419*** | 0.00646*** |
| | [0.00117] | [0.00200] | [0.00139] | [0.00231] |
| *tF 0.05 se* | | (0.00281) | | (0.00324) |
| *AR p-value* | | 0.0000 | | 0.0019 |
| Effect size (%) | 49.47 | 88.63 | 25.73 | 39.30 |
| Model | OLS | IV | OLS | IV |
| Adjusted $R^2$ | 0.4304 | | 0.5368 | |
| Effective F-stat | | 16.63 | | 16.63 |
| Cragg-Donald Wald F-stat | | 358.58 | | 358.58 |

Notes: Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Effect size indicates the percent change in the dependent variable relative to its mean when doses of prescription opioids per capita increase from the 25th to the 75th percentile. Standard errors in square brackets are clustered at the CZ level. Using these standard errors, we report * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Leave out | Sample restriction - size | Sample restriction - time | Shift-share IV | Reduced form results

# A 25th to 75th movement in the distribution of opioids increases all opioid mortality by 39%

| Dependent var: | Prescription opioids | | All opioids | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | 0.00374*** | 0.00679*** | 0.00419*** | 0.00646*** |
| | [0.00117] | [0.00200] | [0.00139] | [0.00231] |
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# Results

(i) Direct effects: Opioid-related mortality

(ii) All-cause adult mortality

(iii) Labor market and social assistance benefits

(iv) Crime

(v) Birth and maternal outcomes

# Declines in mortality rates are driven by a reduction in mortality for those 65+ years old

| Dependent variable: | All cause mortality rate | | |
|---|---|---|---|
| | All | 20-64 | 65 plus |
| | (1) | (2) | (3) |
| Prescription opioids pc | -0.284*** | 0.0596 | -1.008** |
| | [0.0950] | [0.0376] | [0.430] |
| *tF 0.05 se* | (0.1333) | (0.0519) | (0.6033) |
| *AR p-value* | 0.0005 | 0.0815 | 0.0090 |
| Effect size (%) | -14.45 | 10.71 | -13.54 |

Notes: All regressions include state times year fixed effects. Each regression is run over a sample of 11,800 observations with 590 clusters. Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Effect size indicates the percent change in the dependent variable relative to its mean when doses of prescription opioids per capita increase from the 25th to the 75th percentile. Standard errors in square brackets are clustered at the CZ level; using these standard errors, we report * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

# Results

(i) Direct effects: Opioid-related mortality

(ii) All-cause adult mortality

(iii) Labor market and social assistance benefits

(iv) Crime

(v) Birth and maternal outcomes

# The opioid crisis did not have an effect on labor market outcomes

| | Labor Market Outcomes | | Social Assistance Programs | | |
|---|---|---|---|---|---|
| Dependent var: | Employment rate | Labor force participation | SSDI | SSI | SNAP |
| | (1) | (2) | (3) | (4) | (5) |
| Prescription opioids pc | -0.00181 | 0.00348 | 0.00574*** | 0.00311** | 0.00982*** |
| | [0.00214] | [0.00239] | [0.00132] | [0.00144] | [0.00299] |
| *tF 0.05 se* | (0.00300) | (0.00335) | (0.00185) | (0.00202) | (0.00420) |
| *AR p-value* | 0.3990 | 0.1152 | 0.0000 | 0.0114 | 0.0000 |
| Effect size (%) | -11.12 | 29.53 | 76.39 | 46.88 | 56.58 |

*Notes:* All regressions include state times year fixed effects. Each regression is run over a sample of 11,800 observations with 590 clusters. Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Effect size indicates the percent change in the respective dependent variable relative to its mean when doses of prescription opioids per capita increase from the 25th to the 75th percentile. Standard errors in square brackets are clustered at the CZ level; using these standard errors, we report * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Labor market - graph  Labor market outcomes by time  Labor market outcomes - Shift-share IV

# The supply of prescription opioids deteriorated socioeconomic conditions

| | Labor Market Outcomes | | Social Assistance Programs | | |
|---|---|---|---|---|---|
| Dependent var: | Employment rate | Labor force participation | SSDI | SSI | SNAP |
| | (1) | (2) | (3) | (4) | (5) |
| Prescription opioids pc | -0.00181 | 0.00348 | 0.00574*** | 0.00311** | 0.00982*** |
| | [0.00214] | [0.00239] | [0.00132] | [0.00144] | [0.00299] |
| *tF 0.05 se* | (0.00300) | (0.00335) | (0.00185) | (0.00202) | (0.00420) |
| *AR p-value* | 0.3990 | 0.1152 | 0.0000 | 0.0114 | 0.0000 |
| Effect size (%) | -11.12 | 29.53 | 76.39 | 46.88 | 56.58 |

*Notes:* All regressions include state times year fixed effects. Each regression is run over a sample of 11,800 observations with 590 clusters. Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Effect size indicates the percent change in the respective dependent variable relative to its mean when doses of prescription opioids per capita increase from the 25th to the 75th percentile. Standard errors in square brackets are clustered at the CZ level; using these standard errors, we report * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Social assistance outcomes - graphs Social assistance outcomes by time Social assistance outcomes - Shift-share IV

# Results

(i) Direct effects: Opioid-related mortality

(ii) All-cause adult mortality

(iii) Labor market and social assistance benefits

(iv) Crime

(v) Birth and maternal outcomes

# Crime increases across the board, mostly driven by property crime

| Dependent var: | Aggregate | Violent crimes | Property |
|---|---|---|---|
| | (1) | (2) | (3) |
| Prescription opioids pc | 275.8*** | 23.22*** | 254.1*** |
| | [71.92] | [7.455] | [66.55] |
| *tF 0.05 se* | (100.908) | (10.459) | (93.374) |
| *AR p-value* | 0.0000 | 0.0001 | 0.0000 |
| Effect size (%) | 60.90 | 39.07 | 64.58 |

*Notes:* All regressions include state times year fixed effects. Each regression is run over a sample of 11,800 observations with 590 clusters. Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Effect size indicates the percent change in the respective dependent variable relative to its mean when doses of prescription opioids per capita increase from the 25th to the 75th percentile. Standard errors in square brackets are clustered at the CZ level; using these standard errors, we report * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Crime rates - graph Crime rates by time Crime rates - Shift-share IV

# Results

(i) Direct effects: Opioid-related mortality

(ii) All-cause adult mortality

(iii) Labor market and social assistance benefits

(iv) Crime

(v) Birth and maternal outcomes

# No effects on infant mortality rate

| Dependent var: | Infant | Birth weight | | Preterm | APGAR score | |
|---|---|---|---|---|---|---|
| | mortality | median | share low | births | All | Infant fatalities |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Prescription opioids pc | -0.0232 | -4.490** | 0.000905 | 0.00141 | -0.0169* | 0.282* |
| | [0.140] | [2.143] | [0.000640] | [0.000937] | [0.00994] | [0.153] |
| *tF 0.05 se* | (0.19643) | (3.00676) | (0.00090) | (0.00131) | (0.01395) | (0.21467) |
| *AR p-value* | 0.8678 | 0.0163 | 0.1272 | 0.1126 | 0.0674 | 0.0383 |
| Effect size (%) | -1.83 | -0.69 | 5.58 | 5.85 | -0.91 | 25.17 |

*Notes:* All regressions include state times year fixed effects. Each regression is run over a sample of 11,800 observations with 590 clusters. Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Effect size indicates the percent change in the respective dependent variable relative to its mean when doses of prescription opioids per capita increase from the 25th to the 75th percentile. Standard errors in square brackets are clustered at the CZ level; using these standard errors, we report * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Infants' outcomes - graphs Infants' outcomes by time Infants' outcomes - Shift-share IV

# Deterioration of infant health at birth: Reduction in birth weight and APGAR score

| Dependent var: | Infant | Birth weight | | Preterm | APGAR score | |
|---|---|---|---|---|---|---|
| | mortality | median | share low | births | All | Infant fatalities |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Prescription opioids pc | -0.0232 | -4.490** | 0.000905 | 0.00141 | -0.0169* | 0.282* |
| | [0.140] | [2.143] | [0.000640] | [0.000937] | [0.00994] | [0.153] |
| *tF 0.05 se* | (0.19643) | (3.00676) | (0.00090) | (0.00131) | (0.01395) | (0.21467) |
| *AR p-value* | 0.8678 | 0.0163 | 0.1272 | 0.1126 | 0.0674 | 0.0383 |
| Effect size (%) | -1.83 | -0.69 | 5.58 | 5.85 | -0.91 | 25.17 |

*Notes:* All regressions include state times year fixed effects. Each regression is run over a sample of 11,800 observations with 590 clusters. Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Effect size indicates the percent change in the respective dependent variable relative to its mean when doses of prescription opioids per capita increase from the 25th to the 75th percentile. Standard errors in square brackets are clustered at the CZ level; using these standard errors, we report * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Infants' outcomes by time  Infants' outcomes - Shift-share IV

# Median length of pregnancy decreases by 0.24 weeks

| Dependent var: | Gestation | Fertility rate | Adequacy of care |
|---|---|---|---|
| | (1) | (2) | (3) |
| Prescription opioids pc | -0.0489*** | 0.00153*** | 0.00292 |
| | [0.0186] | [0.000566] | [0.00531] |
| *tF 0.05 se* | (0.02610) | (0.00079) | (0.00745) |
| *AR p-value* | 0.0011 | 0.0010 | 0.5771 |
| Effect size (%) | -0.62 | 9.41 | 1.82 |

*Notes:* All regressions include state times year fixed effects. Each regression is run over a sample of 11,800 observations with 590 clusters. Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Effect size indicates the percent change in the respective dependent variable relative to its mean when doses of prescription opioids per capita increase from the 25th to the 75th percentile. Standard errors in square brackets are clustered at the CZ level; using these standard errors, we report * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

# A 25th-to-75th-percentile increase in opioids increases fertility by 9%

| Dependent var: | Gestation | Fertility rate | Adequacy of care |
|---|---|---|---|
| | (1) | (2) | (3) |
| Prescription opioids pc | -0.0489*** | 0.00153*** | 0.00292 |
| | [0.0186] | [0.000566] | [0.00531] |
| *tF 0.05 se* | (0.02610) | (0.00079) | (0.00745) |
| *AR p-value* | 0.0011 | 0.0010 | 0.5771 |
| Effect size (%) | -0.62 | 9.41 | 1.82 |

*Notes:* All regressions include state times year fixed effects. Each regression is run over a sample of 11,800 observations with 590 clusters. Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Effect size indicates the percent change in the respective dependent variable relative to its mean when doses of prescription opioids per capita increase from the 25th to the 75th percentile. Standard errors in square brackets are clustered at the CZ level; using these standard errors, we report * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Fertility rate by time Fertility rate - Shift-share IV Fertility rate by age

# Robustness checks

- On the validity of the empirical strategy.
  - Lagged cancer mortality does not predict future opioid mortality. Reduce-form results
  - Alternative measures of mortality (e.g.,cardiovascular disease) do not predict prescription opioid mortality. Placebo check
  - Implement a shift-share research design and results are quantitatively indistinguishable. Opioids mortality Labor market outcomes Crime rates Infants' outcomes Fertility rate
- Results are robust to alternative sample restrictions on the size of a commuting zone. First stage Pres. opioids All opioids
- Results are not driven by a particular state. First stage Pres. opioids All opioids
- Results are robust to alternative definitions of opioid mortality. Opioid mortality definition
- Results remain unchanged when adding labor market outcomes as control variables. Results with labor market controls

# Agenda

1. Context: The Opioid Epidemic
2. OxyContin & the Marketing of Prescription Opioids
3. Data
4. Empirical Strategy
5. Results
6. **Policy Implications & Conclusions**

# Policy Implications & Conclusions

- We document that the marketing and promotion by pharmaceuticals ignited the opioid epidemic.
- Increasing the supply of prescription opioids:
  - Increased mortality from opioids.
  - Decreased old-age mortality.
  - Increased the demand for SNAP, SSDI; & SSI.
  - Had no effect on broad labor market outcomes.
  - Deteriorated birth outcomes.
  - Increased fertility.

# Policy Implications & Conclusions

- Our results have direct policy implications regarding the desirability of promotional efforts by pharmaceutical companies that target physicians, pharmacies, and patients
- We document the devastating consequences of aggressive and deceitful marketing:
  - Monitor/limit/disclose promotional efforts by pharmaceuticals.
  - Provide age-and diagnosis-specific drug risk profiles.
  - Drug-abuse reporting systems.

Thank you

Comments/questions are welcome

# Appendix

# Where are opioids mostly prescribed?

- No relationship with economic or employment conditions (Ruhm, 2018; Currie et al., 2019; Currie et al., 2020),
- Places with more physicians per capita, higher levels of income and education, lower Medicare spending per capita, and higher scores on a healthcare quality index have higher opioids abuse rates (Finkelstein et al., 2019).
- Medicare Part D: 10% increase in opioid medical supply leads to a 7.1% increase in opioid-related deaths ( Powell et al., 2020)
- Opioids are also disproportionally prescribed to whites (Pletcher et al., 2008).

# Context: Who uses and abuses pain medications?

| | Use of pain killers | Misuse of painkillers | | Use of pain killers | Misuse of painkillers |
|---|---|---|---|---|---|
| Female | 0.0537*** | -0.000906 | Health insurance | 0.0559*** | -0.0101*** |
| | [12.33] | [-0.51] | | [7.38] | [-3.25] |
| 18 to 25 years | 0.0402*** | 0.00318 | Unemployed | 0.0239** | 0.0196*** |
| | [2.96] | [0.57] | | [2.29] | [4.56] |
| 26-34 years | 0.0822*** | -0.00215 | White | 0.0473*** | 0.00902*** |
| | [6.06] | [-0.39] | | [10.17] | [4.73] |
| 35 and older | 0.124*** | -0.0188*** | Use alcohol & tobacco | 0.224*** | 0.225*** |
| | [9.92] | [-3.65] | | [18.91] | [46.27] |
| Some college or more | -0.00049 | 0.000999 | Use of hard drugs | 0.0888*** | 0.0203*** |
| | [-0.10] | [0.50] | | [17.21] | [9.58] |
| Income below 40k | 0.0480*** | 0.00418** | Observations | 47310 | 47310 |
| | [9.87] | [2.10] | $R^2$ | 0.028 | 0.057 |
| | | | Mean Dep. Var | 30% | 4.80% |

NSDUH 2017. Omitted age category 15-17.

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# Prescription Opioid Distribution in 2010

Notes: This map shows the distribution of prescription opioids in 2010. Lighter shades indicate commuting zones with a lower supply and darker shades indicate commuting zones with a higher supply. Each group corresponds to one quartile of the prescription opioid distribution; i.e., each color accumulates 25% of the mass of this distribution.

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# Any Opioid Mortality Rate 1999 - 2018

Notes: This map shows the distribution of opioid mortality for the period 1999 - 2018. Lighter shades indicate commuting zones with lower opioid mortality, while darker shades indicate commuting zones with higher opioid mortality. Each group corresponds to one quartile of the opioid mortality distribution; i.e., each color accumulates 25% of the mass of this distribution.

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# Distribution of Cancer Mortality 1994 & 1996

Notes: This map shows the cancer mortality rate at commuting-zone level in 1994 - 1996. Lighter shades indicate commuting zones with lower cancer prevalence, while darker shades indicate commuting zones with higher cancer prevalence. Each group corresponds to one quartile of the cancer mortality distribution; i.e., each color accumulates 25% of the mass of this distribution.

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# Determinants of opioids distribution in 2000

| Dependent variable: Prescription opioids per capita | | | | | |
|---|---|---|---|---|---|
| | (1) | | (2) | | (3) |
| *Demographics (in shares)* | | *Social assistance* | | *Crime (in rates)* | |
| White | 3.526*** | SSDI | 48.45*** | Overall | -0.0000622 |
| | [0.961] | | [9.821] | | [0.0000752] |
| Hispanic | -3.323*** | SSI | 5.740 | Violent | 0.00160*** |
| | [0.807] | | [8.944] | | [0.000614] |
| Female | 6.709 | SNAP | -1.914 | *Health outcomes* | |
| | [9.973] | | [3.848] | Cancer mortality rate | -0.164 |
| Aged 18-65 | 21.67*** | | | | [0.330] |
| | [4.348] | *Economic characteristics* | | Infant mortality rate | -0.0117 |
| Aged +66 | 6.211 | Ln income | 2.517*** | | [0.0199] |
| | [7.665] | | [0.922] | Birth weight | 0.000336 |
| Infants | -100.8* | Sh. below poverty line | 0.0521 | | [0.00127] |
| | [56.42] | | [0.0625] | Share preterm births | 2.330 |
| *Labor market* | | Sh. employed in manufacturing | -0.0374*** | | [4.796] |
| Employment rate | -16.18*** | | [0.0105] | Gestation | -0.200 |
| | [6.031] | Sh. w/ some college education | 0.00938 | | [0.396] |
| Labor force participation | -1.805 | | [0.0135] | Fertility rate | 52.51*** |
| | [2.493] | | | | [14.07] |

Notes: This table presents estimated coefficients from a cross-section regression of prescription opioid distribution per capita on demographic characteristics, labor market outcomes, measures of social assistance demand, crime outcomes, economic characteristics, and health outcomes at commuting-zone level. Standard errors are robust to heteroskedasticity. *$p<0.10$, **$p<0.05$, *** $p<0.01$.

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# All prescription opioids supply by 1994-1996 cancer prevalence

Notes: This figure shows the evolution of prescription opioids in the forth quartile (solid lines) and first quartile (dashed lines) of the cancer mortality rate distribution before the launch of OxyContin. Prescription opioids are measured in morphine-equivalent mg.

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# All prescription opioids supply and cancer mortality by 1994-1996 cancer prevalence

Notes: The left-hand axis shows the evolution of oxycodone in the fourth quartile (solid lines) and first quartile (dashed lines) of the cancer mortality rate distribution before the launch of OxyContin. The right-hand axis shows the evolution of cancer mortality in the top and bottom quartiles of the cancer mortality distribution before the launch of OxyContin. Oxycodone is measured in morphine-equivalent mg.

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# Estimates of the first stage: Leave out one state at a time

*Notes:* This graph reports the estimated coefficient of the first stage ($\phi$) and the corresponding 95% confidence interval. The first coefficient and confidence interval replicate the result when all states are included in the sample. Each of the subsequent coefficients are computed by excluding all commuting zones in the state indicated on the horizontal axis.

Back Robustness summary

# Estimates of the first stage under alternative sample restrictions

| Dependent variable: | Prescription opioids per capita | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Cancer MR 94-96 | 1.078*** | 1.191*** | 1.055*** | 1.018*** |
| *t-stat* | 4.083 | 4.79 | 3.55 | 3.54 |
| Observations | 11,800 | 12,820 | 10,8880 | 9,620 |
| Clusters | 590 | 641 | 544 | 481 |
| Adjusted $R^2$ | 0.564 | 0.467 | 0.568 | 0.608 |
| Sample | 25,000+ | 15,000+ | 40,000+ | 55,000+ |

Notes: Our preferred specification restricts the sample to commuting zones with population higher than 25,000 residents and is presented in column (1). All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Back Robustness summary

# Estimates of the first stage under alternative sample periods

| Dependent variable: | Prescription Opioids pc | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Cancer MR 94-96 | 1.078*** | 0.916*** | 1.047*** | 1.474*** |
| *se* | [0.264] | [0.258] | [0.277] | [0.330] |
| *t-stat* | 4.08 | 3.55 | 3.78 | 4.46 |
| Observations | 11,800 | 7,080 | 8,850 | 5,310 |
| Adjusted $R^2$ | 0.564 | 0.565 | 0.582 | 0.425 |
| Sample | 1999-2018 | 1999-2010 | 1999-2013 | 2010-2018 |

Notes: Column (1) reproduces the main results for 1999-2018; column (2) presents estimates for the first wave of the opioid epidemic; column (3) presents estimates for the first and second waves pooled together, and column (4) presents estimates for the after-OxyContin reformulation period. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level . * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Estimates of the first stage using oxycodone as dependent variable

| Dependent var: | Presc. Opioids pc (1) | Oxycodone pc (2) | Presc. Opioids pc (3) |
|---|---|---|---|
| Cancer MR 94-96 | 1.078*** | 0.605*** | 0.00417*** |
| *se* | [0.264] | [0.186] | [0.000997] |
| *t-stat* | 4.083 | 3.253 | 4.183 |
| *Effective F-stat* | 16.63 | 10.580 | 17.47 |
| Effect size (%) | 63.92 | 38.00 | |
| Model | FS | FS | FS - Shift share IV |
| Observations | 11,800 | 11,800 | 11,800 |
| Clusters | 590 | 590 | 590 |

Notes: Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years, share of Black, White, and Hispanic population, and share of female population. Effect size is computed as the predicted changes in doses of prescription opioids per capita from an increase in cancer mortality that would change a commuting zone in the 5th percentile of the cancer distribution to the 95th percentile. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Estimates of the first stage using a shift-share instrument

| Dependent var: | Presc. Opioids pc (1) | Oxycodone pc (2) | Presc. Opioids pc (3) |
|---|---|---|---|
| Cancer MR 94-96 | 1.078*** | 0.605*** | 0.00417*** |
| *se* | [0.264] | [0.186] | [0.000997] |
| *t-stat* | 4.083 | 3.253 | 4.183 |
| *Effective F-stat* | 16.63 | 10.580 | 17.47 |
| Effect size (%) | 63.92 | 38.00 | |
| Model | FS | FS | FS - Shift share IV |
| Observations | 11,800 | 11,800 | 11,800 |
| Clusters | 590 | 590 | 590 |

Notes: Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years, share of Black, White, and Hispanic population, and share of female population. Effect size is computed as the predicted changes in doses of prescription opioids per capita from an increase in cancer mortality that would change a commuting zone in the 5th percentile of the cancer distribution to the 95th percentile. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Marketing of prescription opioids had a positive effect on prescription opioid mortality

Notes: This figure shows the evolution of prescription opioid mortality by 1994-1996 cancer prevalence. The high-cancer mortality rate corresponds to the group of commuting zones in the fourth quartile of cancer mortality in 1994-1996, and low cancer corresponds to the first quartile. The vertical line at 1996 indicates the year OxyContin was launched.

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# Marketing of prescription opioids had a positive effect on opioid-related mortality

| Dependent var: | Prescription opioids | All opioids |
|---|---|---|
| | (1) | (2) |
| Cancer MR 94-96 | 0.00732*** | 0.00697*** |
| | [0.00167] | [0.00229] |
| Model | RF | RF |
| Observations | 11,800 | 11,800 |
| Clusters | 590 | 590 |
| Adj $R^2$ | 0.3908 | 0.5144 |

Notes: Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# What does a 25th-to-75th-percentile shift in the distribution of opioids represent?

- An increase of 5.02 doses.
- From 1999 to 2010, the median number of doses increased from 2.03 to 7.40 (5.37 doses).

Direct effects

# Effects on prescription opioid mortality: Leave out one state at a time

*Notes:* This graph shows the estimated coefficient of the IV regression on prescription opioid mortality, instrumenting oxycodone shipments with cancer mortality in 1994-1996. The first coefficient and confidence interval replicate the result when all states are included in the sample. Each of the subsequent coefficients are computed by excluding all commuting zones in the state indicated on the horizontal axis.

Back Robustness summary

# Effects on prescription opioid mortality for different sample restrictions

| Dependent variable: | Prescription opioids mortality rate | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | 0.00679*** | 0.00355*** | 0.00684*** | 0.00826*** |
| *t-stat* | 3.35 | 2.65 | 2.96 | 3.08 |
| Observations | 11,800 | 12,820 | 10,880 | 9,620 |
| Clusters | 590 | 641 | 544 | 481 |
| Sample | 25,000+ | 15,000+ | 40,000+ | 55,000+ |

Notes: Our preferred specification restricts the sample to commuting zones with population higher than 25,000 residents and is presented in column (1). All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Back Robustness summary

# Effects on prescription opioid mortality for different time periods

| Dependent variable: | Prescription opioid mortality rate | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | 0.00679*** | 0.00785*** | 0.00769*** | 0.00533*** |
| | [0.00200] | [0.00259] | [0.00230] | [0.00169] |
| Observations | 11,800 | 7,080 | 8,850 | 5,310 |
| *Effective F-stat* | 16.63 | 12.62 | 14.25 | 19.90 |
| Sample | 1999-2018 | 1999-2010 | 1999-2013 | 2010-2018 |

Notes: Column (1) reproduces the main results for 1999-2018; column (2) presents estimates for the first wave of the opioid epidemic; column (3) presents estimates for the first and second waves pooled together; and column (4) presents estimates for the after-OxyContin reformulation period. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Effects on prescription opioid mortality baseline IV and shift-share IV design

| Dependent var: | Prescription opiod mortality rate | | All opioids mortality rate | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | 0.00679*** | 0.00644*** | 0.00646*** | 0.00635*** |
| | [0.00200] | [0.00188] | [0.00231] | [0.00219] |
| Model | IV | Shift-share IV | IV | Shift-share IV |

Notes: Columns (1) and (3) reproduce the main results and columns (2) and (4) present estimates from IV regressions using the shift-share instrument. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Effects on all opioid mortality: Leave out one state at a time

*Notes:* This graph shows the estimated coefficient of the IV regression on prescription opioid mortality, instrumenting oxycodone shipments with cancer mortality in 1994-1996. The first coefficient and confidence interval replicate the result when all states are included in the sample. Each of the subsequent coefficients are computed by excluding all commuting zones in the state indicated on the horizontal axis.

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# Effects on all opioids mortality for different sample restrictions

| Dependent variable: | All opioids mortality rate | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | 0.00646*** | 0.00152 | 0.00697** | 0.00885*** |
| *t-stat* | 2.77 | 0.89 | 2.56 | 2.69 |
| Observations | 11,800 | 12,820 | 10,880 | 9,620 |
| Clusters | 590 | 641 | 544 | 481 |
| Sample | 25,000+ | 15,000+ | 40,000+ | 55,000+ |

Notes: Our preferred specification restricts the sample to commuting zones with population higher than 25,000 residents is presented in column (1). All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Effects on all opioids mortality for different time periods

| Dependent variable: | All opioids mortality rate | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | 0.00646*** | 0.00677*** | 0.00672*** | 0.00562** |
| | [0.00231] | [0.00256] | [0.00232] | [0.00237] |
| Observations | 11,800 | 7,080 | 8,850 | 5,310 |
| *Effective F-stat* | 16.63 | 12.62 | 14.25 | 19.90 |
| Sample | 1999-2018 | 1999-2010 | 1999-2013 | 2010-2018 |

Notes: Column (1) reproduces the main results for 1999-2018; column (2) presents estimates for the first wave of the opioid epidemic; column (3) presents estimates for the first and second waves pooled together; and column (4) presents estimates for the after-OxyContin reformulation period. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Effects on all opioids mortality baseline IV and shift-share IV design

| Dependent var: | Presc. opiods mortality rate | | All opioids mortality rate | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | 0.00679*** | 0.00644*** | 0.00646*** | 0.00635*** |
| | [0.00200] | [0.00188] | [0.00231] | [0.00219] |
| Model | IV | Shift-share IV | IV | Shift-share IV |

Notes: Columns (1) and (3) reproduce the main results and columns (2) and (4) present estimates from IV regressions using the shift-share instrument. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Labor force participation rate by 1994-1996 cancer prevalence

*Notes:* Solid line: high cancer mortality rate. Dashed line: low cancer mortality rate. This figure shows the evolution of our main outcomes of interest by 1994-1996 cancer prevalence. The high-cancer mortality rate corresponds to the group of commuting zones in the fourth quartile of cancer mortality in 1994-1996 and low cancer corresponds to the first quartile. The vertical line at 1996 indicates the year OxyContin was launched.

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# Employment rate by 1994-1996 cancer prevalence

*Notes:* Solid line: high cancer mortality rate. Dashed line: low cancer mortality rate. This figure shows the evolution of our main outcomes of interest by 1994-1996 cancer prevalence. The high-cancer mortality rate corresponds to the group of commuting zones in the fourth quartile of cancer mortality in 1994-1996 and low cancer corresponds to the first quartile. The vertical line at 1996 indicates the year OxyContin was launched.

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# Labor market outcomes by time

| Dependent var: | Labor force participation | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | 0.00348 | 0.0115*** | 0.00792** | -0.000297 |
| | [0.00239] | [0.00423] | [0.00321] | [0.00196] |
| Observations | 11,800 | 7,080 | 8,850 | 5,310 |
| Effective F | 16.63 | 15.22 | 17.06 | 25.7 |
| Sample | 1999-2018 | 1999-2010 | 1999-2013 | 2010-2018 |

Notes: Column (1) reproduces the main results for 1999-2018; column (2) presents estimates for the first wave of the opioid epidemic; column (3) presents estimates for the first and second waves pooled together; and column (4) presents estimates for the after-OxyContin reformulation period. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Labor market outcomes using a shift-share IV

| Dependent var: | Employment rate | | Labor force participation | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | -0.00181 | -0.00262 | 0.00348 | 0.00273 |
| | [0.00214] | [0.00196] | [0.00239] | [0.00213] |
| Effective F | 16.63 | 17.47 | 16.63 | 17.47 |
| Model | IV | Shift-share IV | IV | Shift-share IV |

Notes: Columns (1) and (3) reproduce the main results and columns (2) and (4) present estimates from IV regressions using the shift-share instrument. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# SSDI evolution by 1994-1996 cancer mortality rate

*Notes:* Solid line: high cancer mortality rate. Dashed line: low cancer mortality rate. This figure shows the evolution of our main outcomes of interest by 1994-1996 cancer prevalence. The high-cancer mortality rate corresponds to the group of commuting zones in the fourth quartile of cancer mortality in 1994-1996 and low cancer corresponds to the first quartile. The vertical line at 1996 indicates the year OxyContin was launched.

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# SSI evolution by 1994-1996 cancer mortality rate

*Notes:* Solid line: high cancer mortality rate. Dashed line: low cancer mortality rate. This figure shows the evolution of our main outcomes of interest by 1994-1996 cancer prevalence. The high-cancer mortality rate corresponds to the group of commuting zones in the fourth quartile of cancer mortality in 1994-1996 and low cancer corresponds to the first quartile. The vertical line at 1996 indicates the year OxyContin was launched.

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# SNAP evolution by 1994-1996 cancer mortality rate

*Notes:* Solid line: high cancer mortality rate. Dashed line: low cancer mortality rate. This figure shows the evolution of our main outcomes of interest by 1994-1996 cancer prevalence. The high-cancer mortality rate corresponds to the group of commuting zones in the fourth quartile of cancer mortality in 1994-1996 and low cancer corresponds to the first quartile. The vertical line at 1996 indicates the year OxyContin was launched.

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# Social assistance outcomes by time - SSDI

| Dependent var: | SSDI | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | 0.00574*** | 0.00584*** | 0.00605*** | 0.00718*** |
| | [0.00132] | [0.00144] | [0.00141] | [0.00135] |
| Observations | 11,800 | 7,080 | 8,850 | 5,310 |
| Effective F | 16.63 | 15.22 | 17.06 | 25.7 |
| Sample | 1999-2018 | 1999-2010 | 1999-2013 | 2010-2018 |

Notes: Column (1) reproduces the main results for 1999-2018; column (2) presents estimates for the first wave of the opioid epidemic; column (3) presents estimates for the first and second waves pooled together; and column (4) presents estimates for the after-OxyContin reformulation period. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Social assistance outcomes by time - SSI

| Dependent var: | SSI | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | 0.00311** | 0.00226* | 0.00248* | 0.00320* |
| | [0.00144] | [0.00133] | [0.00141] | [0.00174] |
| Observations | 11,800 | 7,080 | 8,850 | 5,310 |
| Effective F | 16.63 | 15.22 | 17.06 | 25.7 |
| Sample | 1999-2018 | 1999-2010 | 1999-2013 | 2010-2018 |

Notes: Column (1) reproduces the main results for 1999-2018; column (2) presents estimates for the first wave of the opioid epidemic; column (3) presents estimates for the first and second waves pooled together; and column (4) presents estimates for the after-OxyContin reformulation period. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Social assistance outcomes by time - SNAP

| Dependent var: | SNAP | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | 0.00982*** | 0.00455* | 0.00487** | 0.00680*** |
| | [0.00299] | [0.00250] | [0.00219] | [0.00205] |
| Observations | 11,800 | 7,080 | 8,850 | 5,310 |
| Effective F | 16.63 | 15.22 | 17.06 | 25.7 |
| Sample | 1999-2018 | 1999-2010 | 1999-2013 | 2010-2018 |

Notes: Column (1) reproduces the main results for 1999-2018; column (2) presents estimates for the first wave of the opioid epidemic; column (3) presents estimates for the first and second waves pooled together; and column (4) presents estimates for the after-OxyContin reformulation period. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Social assistance outcomes using a shift-share IV

| Dependent var: | SSDI | | SSI | | SNAP | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Pres. opioids pc | 0.00574*** | 0.00553*** | 0.00311** | 0.00319** | 0.00982*** | 0.00927*** |
| | [0.00132] | [0.00127] | [0.00144] | [0.00158] | [0.00299] | [0.00277] |
| Effective F | 16.63 | 17.47 | 16.63 | 17.47 | 16.63 | 17.47 |
| Model | IV | Shift-share IV | IV | Shift-share IV | IV | Shift-share IV |

Notes: Columns (1), (3), and (5) reproduce the main results and columns (2), (4), and (6) present estimates from IV regressions using the shift-share instrument. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Overall crime rate by time

*Notes:* Solid line: high cancer mortality rate. Dashed line: low cancer mortality rate. This figure shows the evolution of our main outcomes of interest by 1994-1996 cancer prevalence. The high-cancer mortality rate corresponds to the group of commuting zones in the fourth quartile of cancer mortality in 1994-1996 and low cancer corresponds to the first quartile. The vertical line at 1996 indicates the year OxyContin was launched.

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# Overall crime rate by time

| Dependent var: | Overall crime rate | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | 275.8*** | 320.8*** | 322.8*** | 363.9*** |
| | [71.92] | [89.26] | [83.61] | [76.31] |
| Observations | 11,800 | 7,080 | 8,850 | 5,310 |
| Effective F | 16.63 | 15.22 | 17.06 | 25.7 |
| Sample | 1999-2018 | 1999-2010 | 1999-2013 | 2010-2018 |

Notes: Column (1) reproduces the main results for 1999-2018; column (2) presents estimates for the first wave of the opioid epidemic; column (3) presents estimates for the first and second waves pooled together; and column (4) presents estimates for the after-OxyContin reformulation period. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Overall crime rate using a shift-share IV

| Dependent var: | Overall crime rate | |
|---|---|---|
| | (1) | (2) |
| Prescription opioids pc | 275.8*** | 258.7*** |
| | [71.92] | [66.83] |
| Effective F | 16.63 | 17.47 |
| Model | IV | Shift-share IV |

Notes: Column (1) reproduces the main results and column (2) presents estimates from IV regressions using the shift-share instrument. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Infant mortality rate by 1994-1996 cancer incidence

*Notes:* Solid line: high cancer mortality rate. Dashed line: low cancer mortality rate. This figure shows the evolution of our main outcomes of interest by 1994-1996 cancer prevalence. The high-cancer mortality rate corresponds to the group of commuting zones in the fourth quartile of cancer mortality in 1994-1996 and low cancer corresponds to the first quartile. The vertical line at 1996 indicates the year OxyContin was launched.

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# Birth weight by 1994-1996 cancer incidence

*Notes:* Solid line: high cancer mortality rate. Dashed line: low cancer mortality rate. This figure shows the evolution of our main outcomes of interest by 1994-1996 cancer prevalence. The high-cancer mortality rate corresponds to the group of commuting zones in the fourth quartile of cancer mortality in 1994-1996 and low cancer corresponds to the first quartile. The vertical line at 1996 indicates the year OxyContin was launched.

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# Infant outcomes' by time - Infant mortality rate

| Dependent var: | Infant mortality rate | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | -0.0232 | 0.0458 | 0.0512 | 0.0846 |
| | [0.140] | [0.185] | [0.160] | [0.113] |
| Observations | 11,800 | 7,080 | 8,850 | 5,310 |
| Effective F | 16.63 | 15.22 | 17.06 | 25.7 |
| Sample | 1999-2018 | 1999-2010 | 1999-2013 | 2010-2018 |

Notes: Column (1) reproduces the main results for 1999-2018; column (2) presents estimates for the first wave of the opioid epidemic; column (3) presents estimates for the first and second waves pooled together; and column (4) presents estimates for the after-OxyContin reformulation period. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Infant outcomes' by time - Birth weight

| Dependent var: | Birth weight | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | -4.490** | -5.989** | -5.093** | -2.915* |
| | [2.143] | [2.811] | [2.316] | [1.623] |
| Observations | 11,800 | 7,080 | 8,850 | 5,310 |
| Effective F | 16.63 | 15.22 | 17.06 | 25.7 |
| Sample | 1999-2018 | 1999-2010 | 1999-2013 | 2010-2018 |

Notes: Column (1) reproduces the main results for 1999-2018, column (2) presents estimates for the first wave of the opioid epidemic, column (3) presents estimates for the first and second waves pooled together, and column (4) presents estimates for the after-OxyContin reformulation period. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Birth and maternal outcomes using a shift-share IV

| Dependent var: | Infant mortality rate | | Birth weight | | Fertility rate | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Presc. opioids pc | -0.0232 | -0.0218 | -4.490** | -4.344** | 0.00153*** | 0.00149*** |
| | [0.140] | [0.120] | [2.143] | [1.964] | [0.000566] | [0.000548] |
| Effective F | 16.63 | 17.47 | 16.63 | 17.47 | 16.63 | 17.47 |
| Model | IV | Shift-share IV | IV | Shift-share IV | IV | Shift-share IV |

Notes: Columns (1), (3), and (5) reproduce the main results and columns (2), (4), and (6) present estimates from IV regressions using the shift-share instrument. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Fertility rate by 1994-1996 cancer incidence

*Notes:* Solid line: high cancer mortality rate. Dashed line: low cancer mortality rate. This figure shows the evolution of our main outcomes of interest by 1994-1996 cancer prevalence. The high-cancer mortality rate corresponds to the group of commuting zones in the fourth quartile of cancer mortality in 1994-1996 and low cancer corresponds to the first quartile. The vertical line at 1996 indicates the year OxyContin was launched.

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# Fertility rate by time

| Dependent var: | Fertility rate | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Prescription opioids pc | 0.00153*** | 0.00210*** | 0.00233*** | 0.00350*** |
| | [0.000566] | [0.000696] | [0.000674] | [0.000778] |
| Observations | 11,800 | 7,080 | 8,850 | 5,310 |
| Effective F | 16.63 | 15.22 | 17.06 | 25.7 |
| Sample | 1999-2018 | 1999-2010 | 1999-2013 | 2010-2018 |

Notes: Column (1) reproduces the main results for 1999-2018; column (2) presents estimates for the first wave of the opioid epidemic; column (3) presents estimates for the first and second waves pooled together; and column (4) presents estimates for the after-OxyContin reformulation period. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Birth and maternal outcomes using a shift-share IV

| Dependent var: | Infant mortality rate | | Birth weight | | Fertility rate | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Presc. opioids pc | -0.0232 | -0.0218 | -4.490** | -4.344** | 0.00153*** | 0.00149*** |
| | [0.140] | [0.120] | [2.143] | [1.964] | [0.000566] | [0.000548] |
| Effective F | 16.63 | 17.47 | 16.63 | 17.47 | 16.63 | 17.47 |
| Model | IV | Shift-share IV | IV | Shift-share IV | IV | Shift-share IV |

Notes: Columns (1), (3), and (5) reproduce the main results and columns (2), (4), and (6) present estimates from IV regressions using the shift-share instrument. All regressions include state times year fixed effects and a set of control variables: contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Effects on fertility rate by age

| **Age group:** | 10-19 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Presc. Opioids pc | -0.00038 | -0.00107 | 0.00327*** | 0.0000223 | -0.00123** | -0.0000851** |
| | [-1.40] | [-0.96] | [2.83] | [0.05] | [-2.47] | [-2.08] |
| *Effective F-stat* | 16.63 | 16.63 | 16.63 | 16.63 | 16.63 | 16.63 |
| Observations | 11,800 | 11,800 | 11,800 | 11,800 | 11,800 | 11,800 |
| Clusters | 590 | 590 | 590 | 590 | 590 | 590 |

Notes: This table presents results of the effect of the prescription opioid supply on the fertility rate of women age 10 to 44 years by age group. Standard errors in square brackets are clustered at the CZ level; using these standard errors, we report * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# First-stage estimates with labor market controls

| Dependent var: | Prescription opioids per capita | |
|---|---|---|
| | (1) | (2) |
| Cancer MR 94-96 | 1.078*** | 1.072*** |
| | [0.264] | [0.264] |
| Effective F | 16.63 | 16.46 |
| Fixed effects | State x Year | State x Year |
| Main controls | Yes | Yes |
| Labor market controls | No | Yes |

Notes: Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Opioid mortality estimates with labor market controls

| Dependent var: | Prescription opioids MR | | All opioids mortality rate | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Cancer MR 94-96 | 0.00679*** | 0.00674*** | 0.00646*** | 0.00639*** |
| | [0.00200] | [0.00200] | [0.00231] | [0.00231] |
| Main controls | Yes | Yes | Yes | Yes |
| Labor market controls | No | Yes | No | Yes |

Notes: Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

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# Additional outcomes estimates with labor market controls

| Dependent var: | SSDI | SSI | SNAP | Crime rate | IMR | Fertility rate |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Cancer MR 94-96* | | | | | | |
| Baseline covariates | 0.00574*** | 0.00311** | 0.00982*** | 275.8*** | -0.0232 | 0.00153*** |
| | [0.00132] | [0.00144] | [0.00299] | [71.92] | [0.140] | [0.000566] |
| Labor market controls | 0.00587*** | 0.00313** | 0.0103*** | 277.0*** | -0.0326 | 0.00148*** |
| | [0.00136] | [0.00141] | [0.00308] | [72.58] | [0.138] | [0.000562] |

Notes: Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years, share of Black, White, and Hispanic population, and share of female population. Standard errors are clustered at commuting-zone level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Robustness summary

# Drug induced mortality

| Dependent var: | Prescription opioids MR | All opioids MR | Drug-induced MR |
|---|---|---|---|
| | (1) | (2) | (3) |
| Prescription opioids pc | 0.00679*** | 0.00646*** | 0.0112*** |
| | [0.00200] | [0.00139] | [0.00369] |
| *tF 0.05 se* | -0.00281 | -0.00324 | -0.00518 |
| *AR p-value* | 0.0000 | 0.0019 | 0.0001 |
| Effect size (%) | 88.63 | 39.3 | 50.71 |

Notes: The drug-induced deaths category includes deaths from poisoning and medical conditions caused by use of legal or illegal drugs, as well as deaths from poisoning due to medically prescribed and other drugs. This category has the advantage that comparisons across years are less affected by changes in the ICD classification. All regressions include state times year fixed effects. Each regression is run over a sample of 11,800 observations with 590 clusters. Control variables are contemporaneous cancer mortality rate, share of population under 1 year old, share of population between 18 and 65, share of population over 66 years old, share of Black, White, and Hispanic population, and share of female population. Effect size indicates the percent change in the respective dependent variable relative to its mean when doses of prescription opioids per capita increase from the 25th to the 75th percentile. Standard errors in square brackets are clustered at commuting-zone level; using these standard errors, we report * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Robustness summary