When Innovation Goes Wrong: Technological Regress and the Opioid Epidemic

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Roadmap

Introduction

- The opioid crisis remains one of the nation's most urgent public health challenges
- It began when Oxycontin was released in 1996 by Purdue Pharma, marketed to chronic pain sufferers:

> For patients suffering from moderate to severe pain which requires treatment for more than a few days, such as the pain associated with arthritis, cancer, injuries, lower back problems, and other musculoskeletal conditions, now there is new OxyContin(TM) (oxycodone HCl controlled-release) Tablets C-II (Warning: May be habit forming) -- the first and only 12-hour oxycodone pain medicine.

Source: LA Times OxyContin files

Introduction

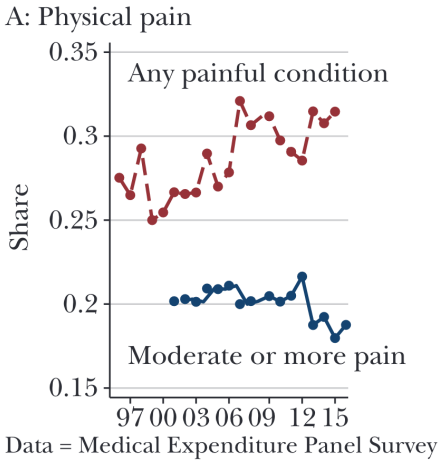
- Overall age-adjusted drug deaths per 100,000 rose from 3.8 in 1990 in 2001 to 20.7 in 2018 (Cutler and Glaeser, 2021) ▸ Trends, 1990-2018
- While no demographic or region has been spared, white non-Hispanic men without a college degree have seen the largest increases in mortality (Case and Deaton, 2015)
- Opioid-related drug overdoses have claimed the lives of nearly 250,000 people since 2018 (Spencer et al., 2022)
  - Rising drug overdoses have become a crisis of synthetic opioids, but stimulants have played a part as well
  - Total drug deaths are now at 32.4 per 100,000 as of 2021 ▸ Trends, 1990-2021
- This crisis is the latest in the cycle of opioid innovation and ties into broader work on the direction of innovation (Acemoglu, 2023) ▸ Model

History

- Opioid development and use has been centuries in the making: Civil War soldiers were frequently given morphine, and heroin was marketed widely in the early 20th century
- Attempts to curtail supply of specific opioids (heroin) were common, but success was limited
- Once OxyContin was introduced, shipments grew by 27 percent annually ▸ Figure
- Majority of growth was intensive margin (more opioids prescribed per person) as patients shiften away from less powerful pain relievers

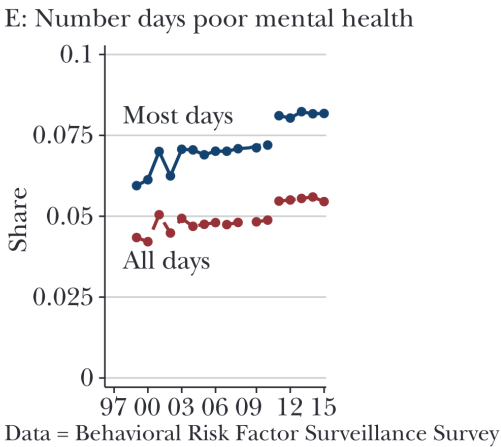
Demand-side factors

- **Physical pain**: Slight rise in painful conditions from 1997 to 2015



Demand-side factors

- **Mental health**: Rising share of poor mental health days (Case and Deaton, 2015)

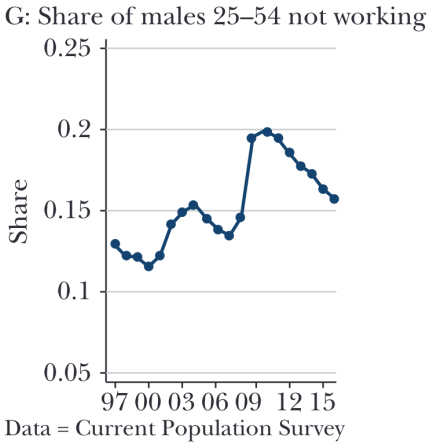


Demand-side factors

- **Despair**: Life satisfaction has remained stable

Demand-side factors

- **Opportunity cost**: Share not working is steadily rising



Demand-side factors

- **Physical pain**: Slight rise in painful conditions from 1997 to 2015
- **Mental health**: Rising share of poor mental health days (Case and Deaton, 2015)
- **Despair**: Life satisfaction has remained stable
- **Opportunity cost**: Share not working is steadily rising
- From the Midlife in the US Survey, only one-quarter of increase in opioids explained by changes in these four factors
- County and CZ-level characteristics eliminate the correlation between economic factors and drug deaths (Ruhm, 2018)

Supply-side factors

- Big shift in supplying opioids for individuals in outpatient settings - driven by Purdue marketing and a small fraction of physicians writing a large share of prescriptions
- Drug monitoring programs and the reformulation of OxyContin resulted in fewer prescriptions, but the illegal market flourished (Alpert et al., 2018)
- Multiple factors (pain, mental health, opioid supply) compounded to drive up mortality

▸ CG (2021) Table 1

Roadmap

Child maltreatment by the numbers

- One percent of children are found to be maltreatment victims in a given year (Bald et al., 2022) ▸ Numbers ▸ Rates
- An estimated 37 percent of children are involved in a CPS investigation and 12 percent are confirmed as victims before age 18 (Kim et al., 2017; Yi et al., 2020)
- Roughly 400,000 children are in foster care at any given point in time ▸ Numbers ▸ Rates
- Parental substance abuse as a reason for foster care placement has become much more common ▸ Table

Disparities in child welfare

- An estimated 53 percent of Black children are involved in a CPS investigation before age 18 (relative to 28 percent of white children) (Kim et al., 2017)
- As many as 12 percent of Black children and 15 percent of American Indian/Alaska Native children experience foster care during childhood (Wildeman and Emanuel 2014) ▸ Disparity ▸ Disproportionality
- The policy of blind removals (concealing race at the decision point of foster care placement) does little to reduce disparities (Baron et al., 2021)
- Causal studies do not find evidence that treatment effects differ by race (Doyle, 2007; Gross and Baron, 2022; Bald et al., 2022)

Health of foster youth

- Childhood abuse and neglect is associated with increased risk of PTSD, alcohol abuse, and developmental/psychosocial problems (Widom et al., 1995; Widom, 1999; Lansford et al., 2002; Deutsch et al., 2015)
- Foster youth are an incredibly high-risk group: they experience more severe maltreatment than the average maltreated child, and as many as one-third experience homelessness (Bald et al., 2022; Dworsky et al., 2013)
- Most foster youth are eligible for Medicaid (and former foster youth may be eligible until age 26)

How might the opioid epidemic affect children?

- Four main pathways (Feder et al., 2019):
  1. Opioid use results in child poisoning: Pediatric hospitalizations for opioid poisoning are rising (Winstanley and Stover, 2019)
  2. Opioid use occurs during pregnancy, affecting infant health: 24 states consider this child abuse (Guttmacher Institute, 2023)
  3. Opioid use results in deprivation of parental care and resources
  4. Opioid use results in separation from parents (due to incarceration, rehabilitation, or death): Opioid death rates are highest for individuals aged 25-44 Buckles et al., 2020

▸ Map of growth in foster care placements due to substance abuse ▸ Comparison with opioid supply

Roadmap

Recap

- Foster care caseloads have risen since 2012 ▸ Figure
- A rising fraction of children are placed as a result of parental substance abuse

  → How much has the opioid epidemic contributed to these trends?
  → Other effects on children's health and welfare?

- Papers: Quast et al., 2018; Buckles et al., 2020; Hou, 2021; Evans et al., 2022; Gihleb et al., 2022

Summary of the literature

Paper	Outcome	Identification	Result
Quast et al. (2018)	Foster care admissions	Panel data from Florida counties 2012-15 with controls	Opioid prescriptions associated with increased removals ▸ Table
Buckles et al. (2020)	Children living away or missing parents	IV: instrument for exposure to drug crisis using Purdue marketing in triplicate vs. non-triplicate states	Large increases in likelihood of a missing parent or living with grandparents ▸ Table
Hou (2021)	Foster care admissions	IV: instrument for illicit and PO deaths using opioid supply in 2000	Illicit opioid abuse is associated with rising total foster care entries, but PO abuse only affects kinship
Gihleb et al. (2022)	Foster care admissions	DiD: Expansion of mandatory prescription drug monitoring programs	Mandatory PDMPs reduce foster care admissions, driven by first removals and younger parents ▸ Table
Evans et al. (2022)	Child maltreatment	DiD: OxyContin reformulation interacted with pre-reform exposure, state variation in PDMPs	1 SD increase in pre-reform exposure increases maltreatment by 3.7% annually ▸ Figure

Directions for future research

- Reconcile different findings in the (early) literature
  - Evans et al. (2022) devotes a long appendix section to why PDMPs increase maltreatment but reduce foster care
- Why are some states with high opioid deaths (the Northeast corridor) not seeing large increases in foster care caseloads? Is this driven by policy?
- What is the effect of parental death from opioids on children's education and health? Are there spillovers to schools or teachers?
- Health and educational outcomes of foster youth
  - National Data Archive on Child Abuse and Neglect (NDACAN) just released a new dataset with linked child welfare and Medicaid records (CCOULD)

Directions for future research

Anonymous mid-semester feedback form for the seminar:

My email: abald@g.harvard.edu

Roadmap

Investigation and maltreatment totals, 2004-2019

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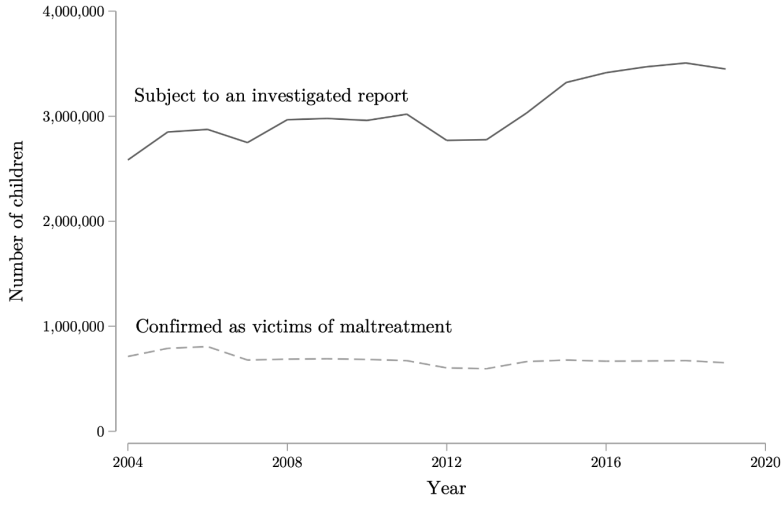

Investigation and maltreatment rates, 2004-2019

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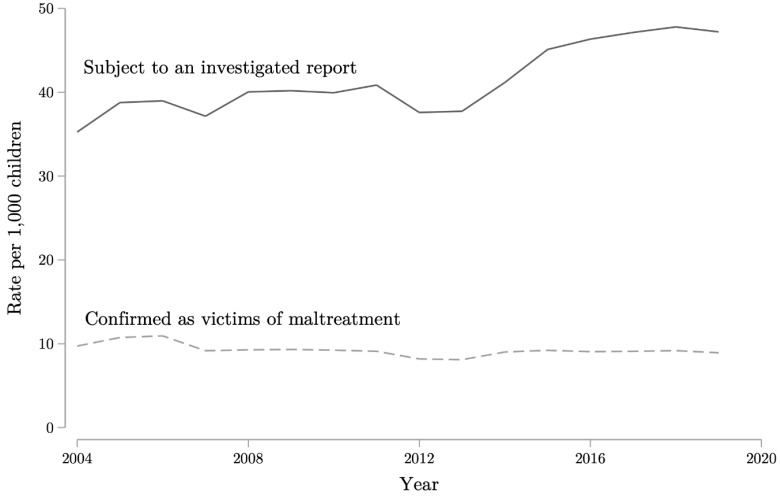

Foster care totals, 2004-2019

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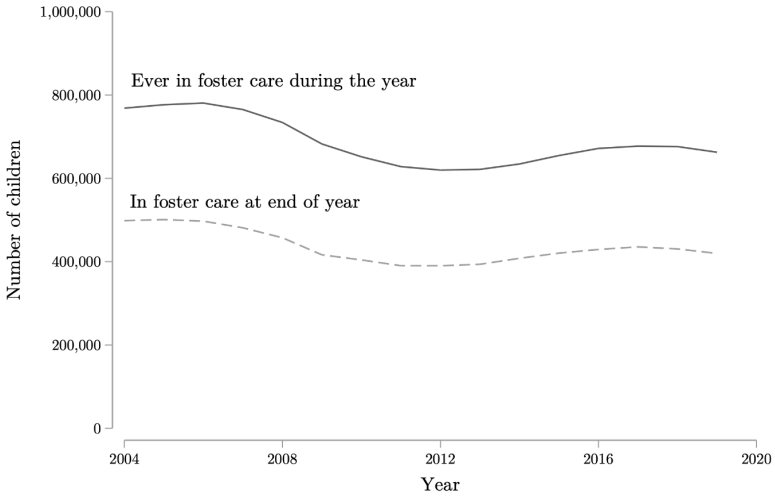

Foster care totals, 2004-2019

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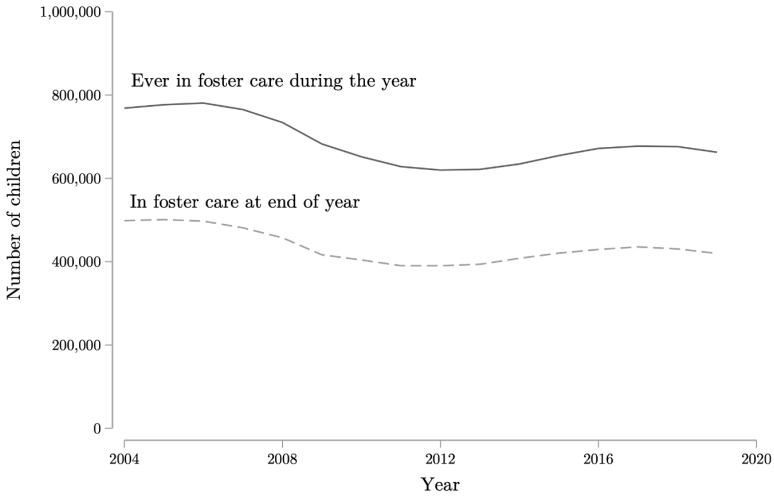

Foster care rates, 2004-2019

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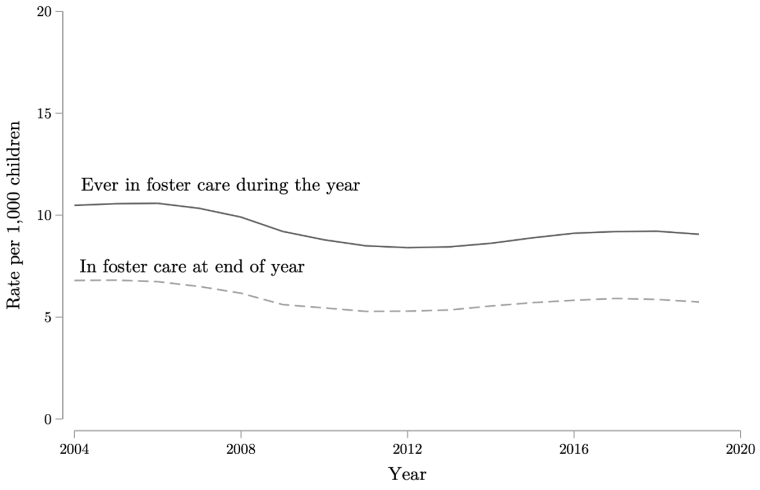

Foster care trends

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	Number in 2019 (1)	*Share in 2004* (2)	*Share in 2019* (3)	*Difference* (3) – (2) (4)
Panel A. Children ages 0–17 (N = 73,039,150)				
Investigated for maltreatment	3,449,674	3.52	4.72	1.19
Confirmed as victims	652,253	0.97	0.89	–0.08
Entered foster care	250,311	0.41	0.34	–0.06
In foster care at end of fiscal year	419,760	0.68	0.57	–0.11
Panel B. Removal reason for children entering care (N = 250,311)				
Removed due to neglect		51.43	63.87	12.44
Removed due to parent substance use		23.34	38.15	14.81
Removed due to physical abuse		16.88	12.94	–3.94
Removed due to sexual abuse		6.33	3.96	–2.37

Disparities by state, 2019

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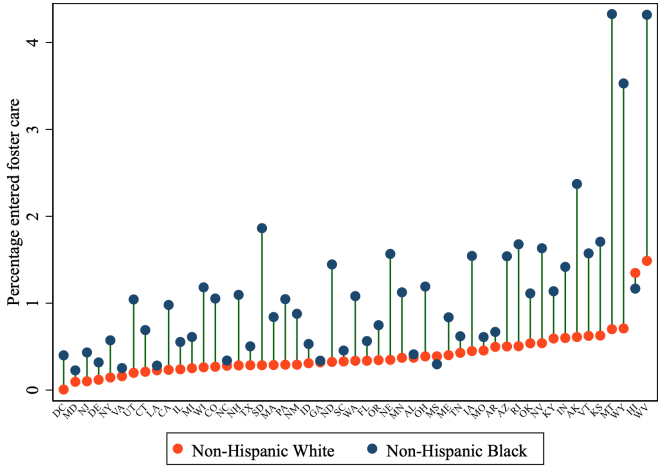

Disproportionality by state, 2019

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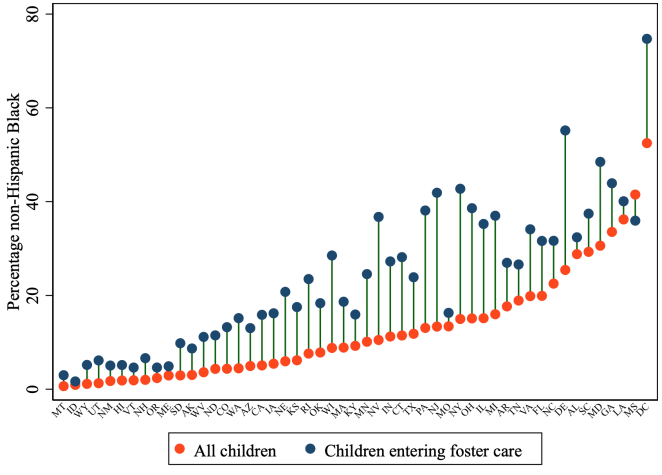

Foster care placements involving substance abuse

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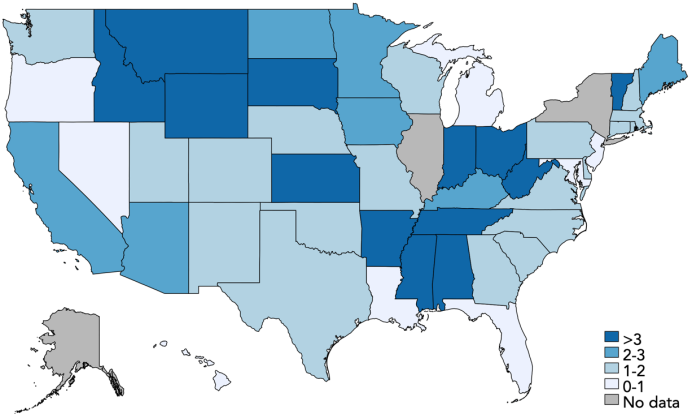
Ratio of 2018 rate to 2004 rate



Comparison of substance abuse placements with opioid supply

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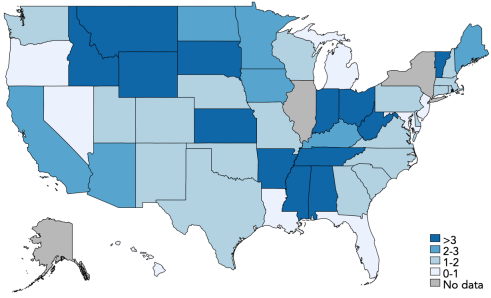
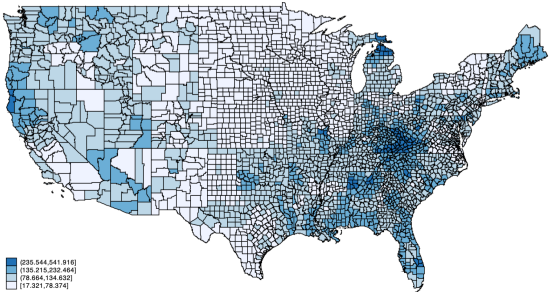
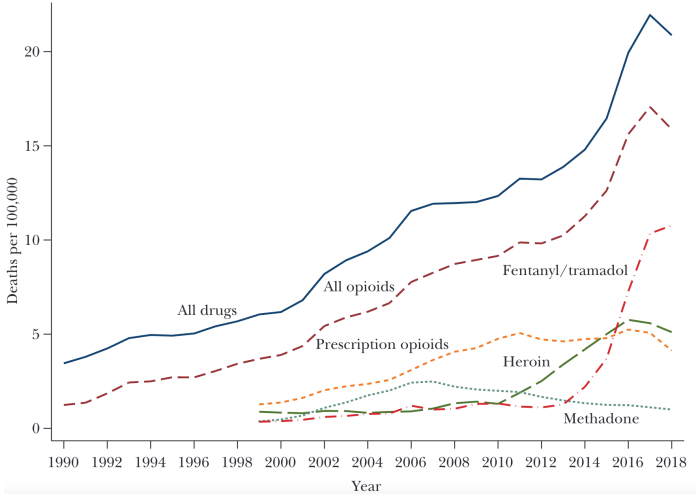


Foster care placements involving substance abuse



Per capital supply of Rx opioids in 2000 (Hou, 2021)

Trends in Age- and Sex-Adjusted Drug Deaths and Opioid Deaths, 1990-2018



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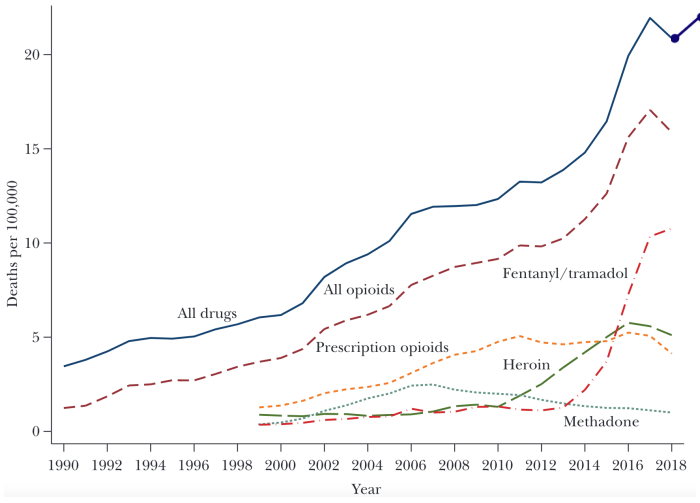
Trends in Age- and Sex-Adjusted Drug Deaths and Opioid Death -2018



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Acemoglu (2023)

The model has the following structure:

- Representative household utility: $U = \ln C + \ln E$, depends on consumption (C, e.g., output) and externalities (E)
- Production function: $Y = \left[\gamma_1 Y_1^{\frac{\varepsilon-1}{\varepsilon}} + \gamma_2 Y_2^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}$, where Y_1 and Y_2 are intermediate goods or sectors (e.g., preventative and curative medicine produce QALYs)
- Intermediate good $Y_j = X_j^{\alpha} R_j^{1-\alpha}$, where R_j are resources priced at q_j^R and X_j is variable input
- Variable input produced as: $X_j = \left(\int_0^{N_j} x_j(\nu)^{1-\beta} d\nu\right) \tilde{L}_j^{\beta}$, where $\tilde{L}_j$ is specialized (inelastic) labor for that sector, N_j is range of technology ν that provides quantity x_j in production

Acemoglu (2023) II

- Technology is produced by scientists S_j: $N_j = \tilde{\eta}_j \phi(S_j) S_j$, with $\phi(S_j) = S_j^{\frac{\delta}{1-\delta}}$ governing sectoral returns to scale
- $\delta > 0$ indicates increasing returns to scale (or path dependence in a dynamic setting)
- Price of machines in sector j given by: $q_j = (1 + \mu_j)\psi$, with constant marginal cost ψ and markup term μ_j
- Externality: $E = e^{-\sum \tilde{\tau}_j \ln N_j}$, $\tilde{\tau}$ representing externalities (negative ext. if > 0, positive ext. if < 0)
- Goal: characterize the equilibrium levels of technology $n^{EQ} = N_2 / N_1$

Acemoglu (2023) III

Social planner's problem is to allocate scientists to maximize total welfare:

$$\max_{S_1, S_2 \geq 0; S_1 + S_2 \leq \bar{S}} \ln Y(N_1, N_2) + \ln E(N_1, N_2)$$

Solves for the ratio of socially optimal and equilibrium technologies:

$$\frac{n^{SP}}{n^{EQ}} = \left[\left(\frac{\mu_2}{\mu_1} \right)^{-1} \left(\frac{1 + \mu_2}{1 + \mu_1} \right) \left(\frac{1 - \tau_2}{1 - \tau_1} \right) \right]^{\frac{\sigma}{1 - \delta\sigma}}$$

Greater externalities and higher markups in sector j distort technology toward sector j.

Acemoglu (2023) IV

Calibration to health care: medical research and disease burden

- External parameters (Table 1): Variable input share (α), labor share (β), markups (μ_1, μ_2, estimated from De Loecker et al., 2020), externalities (τ_1, τ_2)
- Externalities: Returns (in terms of QALYs) to curative medicine (N_2) relative to preventative medicine (N_1):

$$\tilde{\tau}_2 = 1 - \frac{\text{QALY per dollar}_{curative}}{\text{QALY per dollar}_{preventative}} \sim 0.37$$

- Using estimated externalities, he finds $n^{SP} / n^{EQ} \sim 0.59$, with welfare effects at 18% of health care consumption

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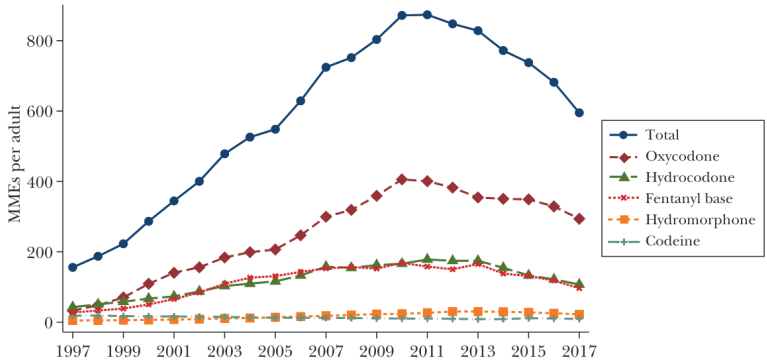
Figure 2

Trends in Opioid Shipments per Adult, 1997–2017



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Impact of Drug Shipments Interacted with Pain and Despair on Local Areas

	Interaction with opioid shipments						*Interaction with national illicit death rate*
	Prescription opioid shipments (1997–2010)					*Prescription opioid death rate (1997–2010)*	*Illicit opioid death rate (2008–2017)*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Interaction between national opioid shipments/illegal deaths and Pain							
Percent of labor force claiming DI (1990)	86.10***				55.90	1.11*	3.02*
	(10.73)				(41.86)	(0.60)	(1.57)
Self-reported joint pain prevalence		65.83**			38.83	0.61**	3.01***
		(31.26)			(32.22)	(0.28)	(1.00)
Despair							
Share dissatisfied/very dissatisfied w/life			33.98		–70.94**	–0.49	1.32
			(28.26)		(29.63)	(0.33)	(1.08)
Extreme mental distress (30 days w/poor mental health)				140.86***	149.03***	1.27***	–0.09
				(28.27)	(36.38)	(0.38)	(1.04)
Opioid shipments							
Oxycodone MME per capita, 1997–2010							4.47***
							(1.11)

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EXHIBIT 3

Associations between rates of child removal and drug prescriptions for all Florida counties, 2012–15

	All causes	Parental drug abuse	Parental neglect
Opioids	0.09	0.07*	0.07**
Benzodiazepines	–0.12	–0.09	–0.06
Stimulants	0.10	0.02	0.03

SOURCE Authors' analysis of removal data for 2012–15 from the Adoption and Foster Care Analysis and Reporting System (see note 31 in text), prescription data from the Florida Drug-Related Outcomes Surveillance and Tracking System (see note 33 in text), population data from the Census Bureau (see note 32 in text), and data from the Census Bureau's Small Area Income and Poverty Estimates program (see note 34 in text). **NOTES** The results are based on regression analysis. The dependent variable is the rate of child removals per 1,000 children ages 0–19 in a given Florida county. The prescription rate is calculated per 100 residents of all ages in a given Florida county. County and year fixed effects and county characteristics are included in all models. There are 268 observations, and observations are clustered by county. An unabridged version of this text is available in the online appendix (see note 37 in text). *$p < 0.10$ **$p < 0.05$

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Dependent variable	Sample mean	OLS	2SLS	p-value Hausman test	Children impacted by movement of the $CEXPOSURE_{ast}$ rate from 1996 to 2015 values: Change in rate per 100,000	Children impacted by movement of the $CEXPOSURE_{ast}$ rate from 1996 to 2015 values: # impacted
Mom not in household/100K	6,304	10.0 (1.99)	12.88 (3.36) [84.3]	0.207	1,291	862,000
Dad not in household/100K	23,890	9.32 (1.89)	9.68 (4.34) [80.4]	0.925	1,436	954,000
Missing at least one parent/100K	27,294	15.52 (3.00)	18.29 (5.63) [92.7]	0.533	2,279	1,517,000
Missing both Mom and Dad/100K	2,900	4.38 (0.78)	3.64 (1.44) [92.7]	0.532	454	302,000
Grandparent head of HH/100K	5,282	2.09 (1.71)	6.02 (2.17) [92.7]	0.061	750	499,000

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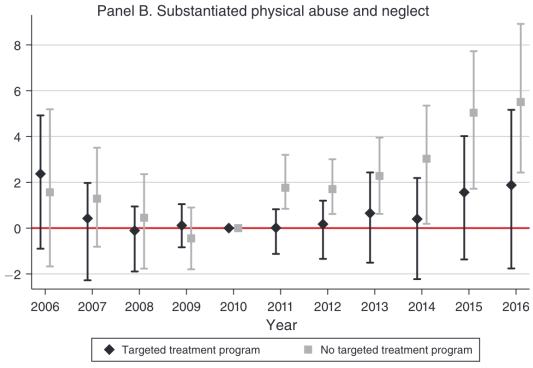

FIGURE 7. OXYCONTIN ANALYSIS—EVENT STUDY RESULTS BY DEDICATED SUBSTANCE USE PROGRAM(S) FOR PREGNANT WOMEN

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Effects of Mandatory PDMPs on Foster Care Admissions (Logs)

Variables	Child Removals (1)	Neglect Cases (2)	Physical Abuses (3)
Post (0–1)	–0.011	–0.019	0.003
	(0.025)	(0.027)	(0.031)
Post (2+)	–0.095**	–0.139***	–0.097*
	(0.042)	(0.048)	(0.050)
Observations	371	371	371
R-squared	0.996	0.995	0.994
Mean of dep. var.	8.019	7.645	6.200
SD of dep. var.	0.908	0.967	0.969

Notes: All estimates include time-varying control at the state level for the share of female, Hispanic, Black, white, foreign-born, noncitizen population, average family income (log), unemployment rate, children population (0–18), year and state fixed effects, state-specific time trends and the following laws/regulations: Good Samaritan laws, Doctor Shopping, Pain Clinic regulations, Physician exams, require ID, and tamper-resistant prescription form requirement. Data on children who were assigned to foster care because of drug-related abuses are drawn from the Adoption and Foster Care Analysis and Reporting System (AFCARS), Foster Care File (2000–2016). The sample is restricted to states that adopted an operational PDMP. Standard errors adjusted for clustering at the state level are reported in parentheses. Significance levels: $*p<0.1$, $**p<0.05$, $***p<0.01$.

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