The Long-Run Economic Effects of Medical Innovation and the Role of Opportunities

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Motivation

- We study the long-run benefits of medical technology to treat pneumonia in infancy and early childhood

- We examine how these benefits vary by context – namely, institutional and societal constraints to opportunity

- Related literature
  - Social value of medical innovation (Murphy and Topel 2006)
  - Early life disease shocks (Almond, Currie and Duque 2018)
  - Systemic discrimination (Darity 2022; Bohren et al 2025; McMillon 2025)

Pneumonia in early 20th century U.S.

- Acute inflammatory disease of the lung that is typically infectious in origin

- Leading cause of morbidity & mortality in 1930s U.S. (Britten 1942)
  - 1 out of every 10 deaths
  - Spells could last up to a month
  - Attack rates highest among infants and older adults

- Prior to antibiotics, treated with supportive care
  - Serum therapy use was growing but not widespread (Podolsky 2006)

Sulfa drugs

- Arrived in 1937
- Widely available without prescription (Lesch 2007)
- Effective for pneumonia
  - Detectable in population-wide pneumonia death rates – 17% decline (Jayachandran, Lleras-Muney, and Smith 2010)

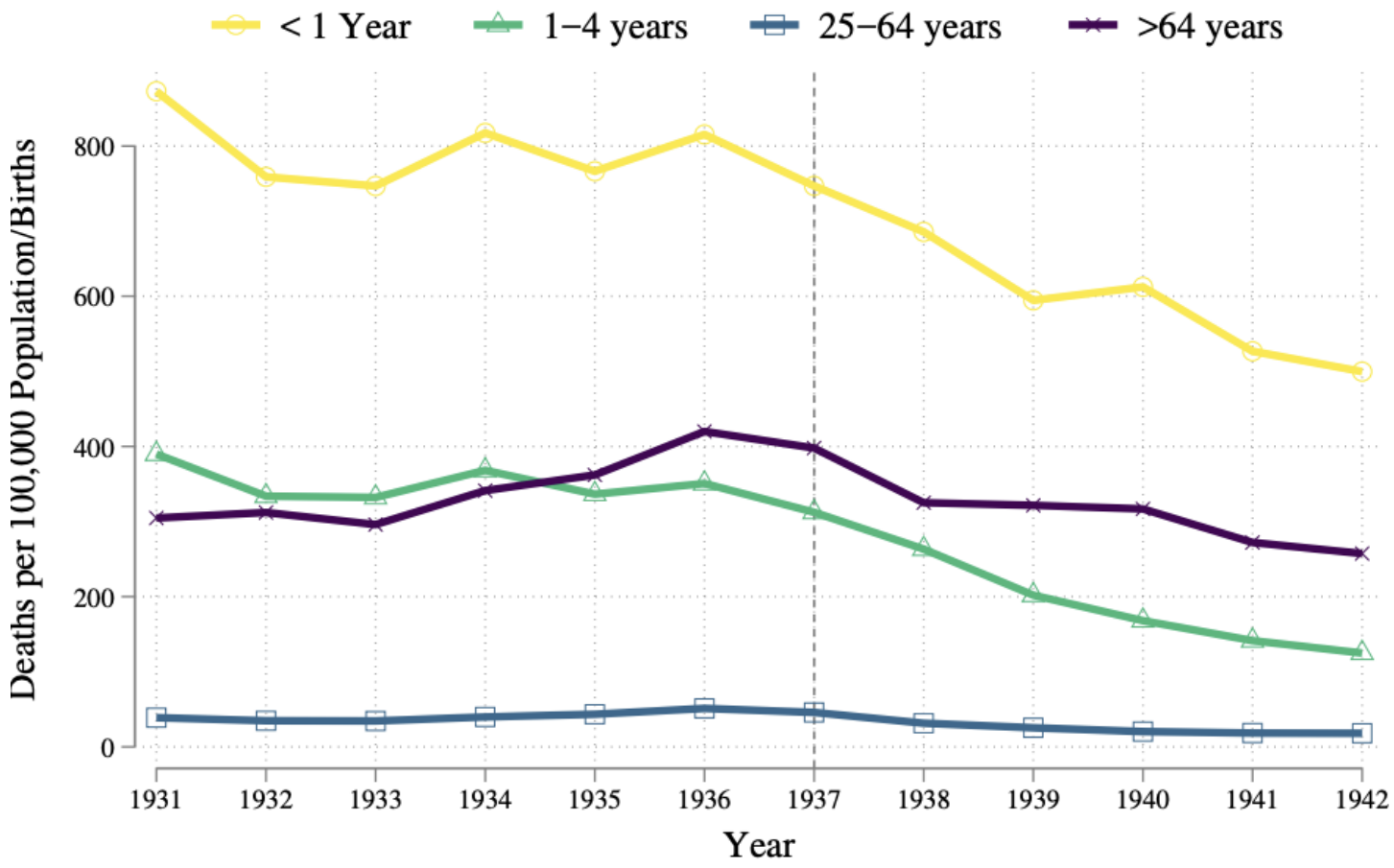
YOUNG ROOSEVELT SAVED BY NEW DRUG

Doctor Used Prontylin in Fight on Streptococcus Infection of the Throat.

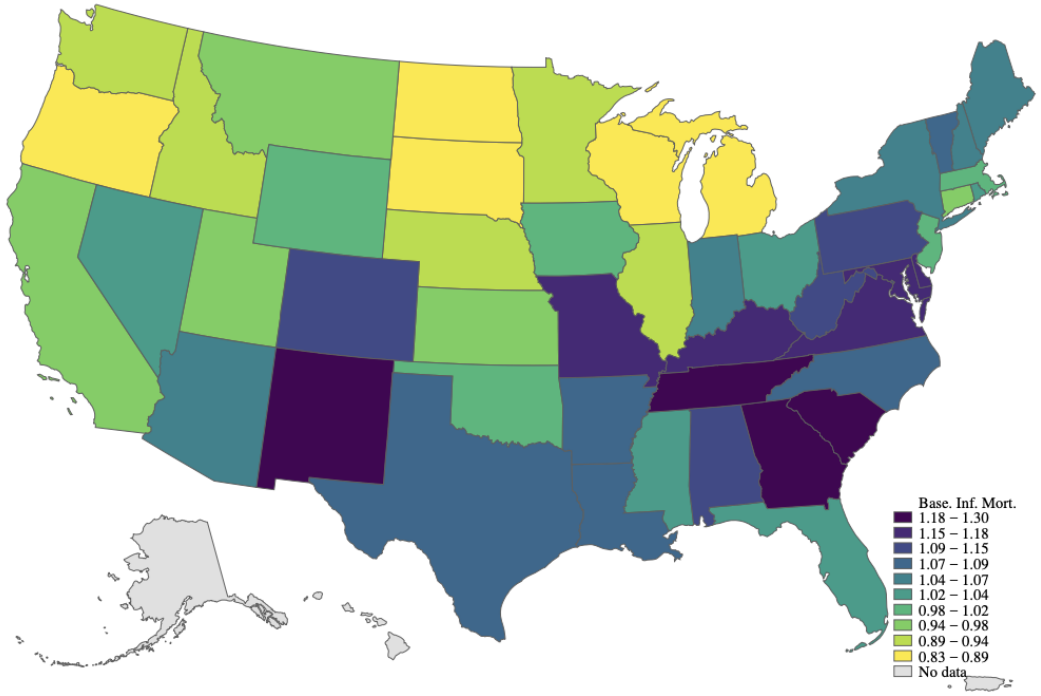
CONDITION ONCE SERIOUS

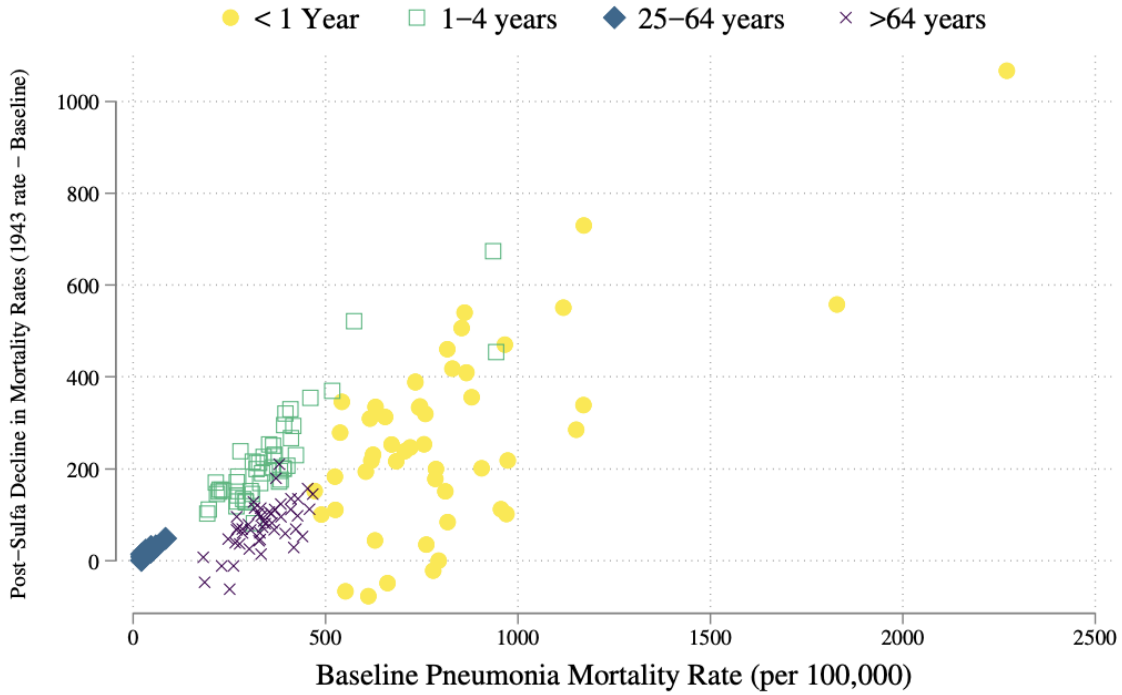
But Youth, in Boston Hospital, Gains Steadily—Fiancee, Reassured, Leaves Bedside.

Trends in pneumonia mortality



Cross-state convergence





Empirical strategy: long-run effects

- Basic idea: assess if sudden cross-state convergence in pneumonia mortality is mirrored in long-run outcomes for affected cohorts

- Follow 1930-1943 birth cohorts in successive U.S. censuses
  - 1980, 1990, 2000

- Focus on birth state-year exposures
  - Birth state available in decennial census
  - Pneumonia morbidity and mortality were highest under age 1
  - Use all-age pneumonia mortality given measurement concerns with infant pneumonia

Continuous DiD setup

$$Y_{istc} = \alpha + \tau\left(\text{Post sulfa}_t \times \text{Base Exposure}_s\right) + \theta_{s,rg} + (\eta_t \times \mu_d)_{rg} + \lambda_{c,rg} + X'_{st}\Gamma + \varepsilon_{istc}.$$

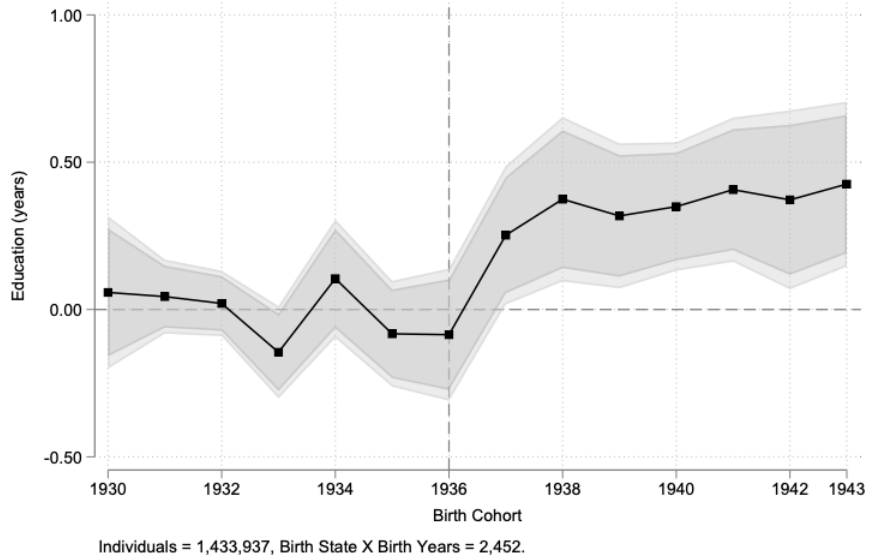
- Control for:
  - FEs for birth state, birth year, census division x cohort, census wave (by race and gender)
  - Sulfa-treatable and non-treatable diseases (interacted with *Post sulfa*)
  - State income, public health spending, education spending (interacted with *Post sulfa*)

Main results

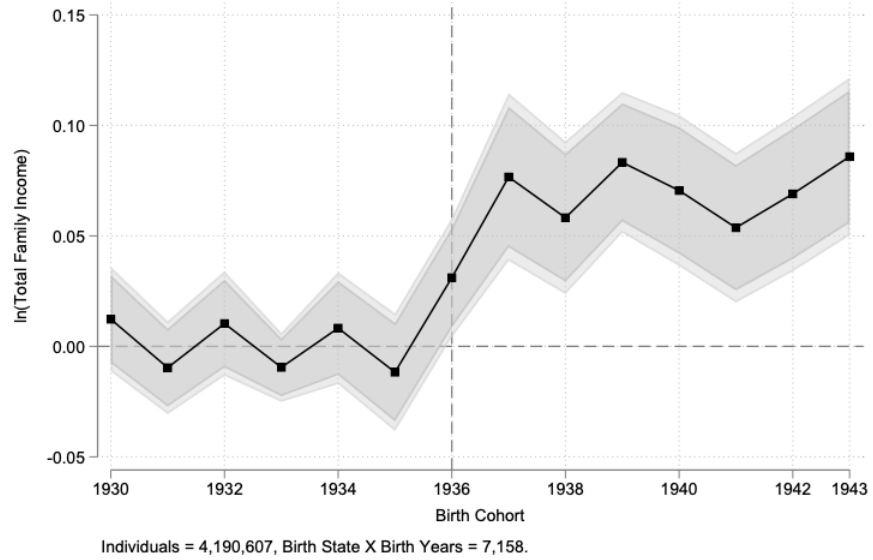
	Schooling	log(Family Income)	Employment	Work Limiting Disability
	(1)	(2)	(3)	(4)
Post Sulfa × Base Exposure	0.199**	0.0497***	0.0172**	-0.00816**
	(0.0872)	(0.0120)	(0.00736)	(0.00354)
FWER p-value	[0.049]	[0.004]	[0.091]	[0.079]
Effect size for an interquartile shift in base exposure	0.0560 years	1.399 %	0.485 pp	-0.230 pp
Observations	1,433,937	4,110,228	4,190,633	4,190,633

Average causal response on the treated = Effect X 6.7

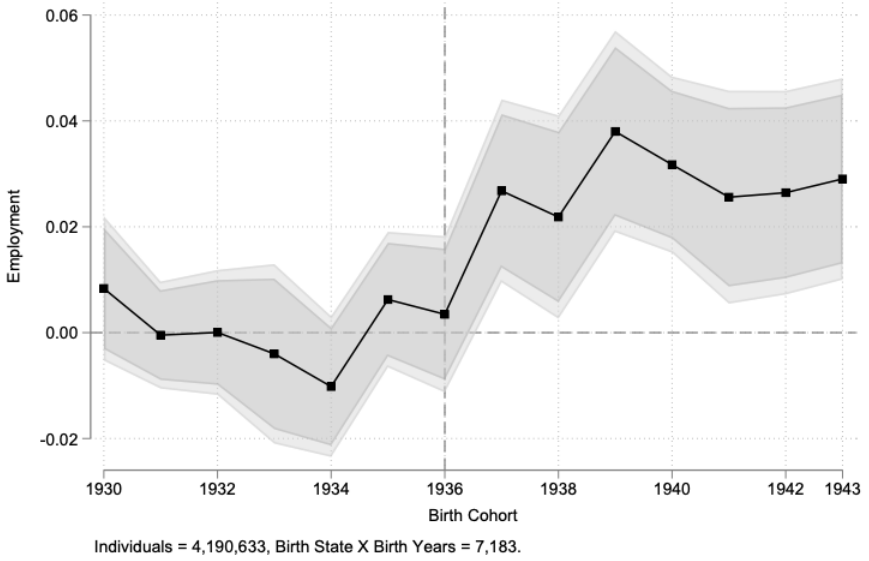
→ Large, but plausible given *significant* morbidity from pneumonia



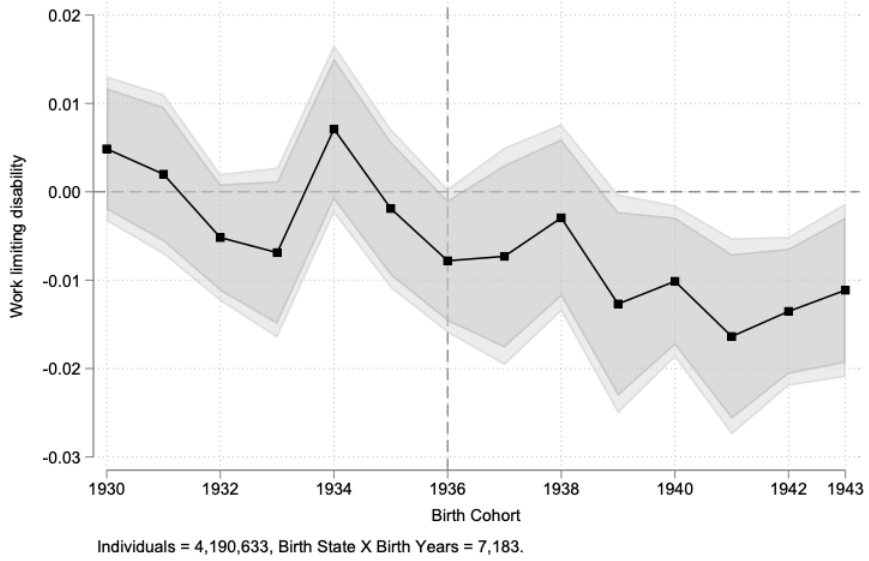
(a) Education



(b) log(Family Income)

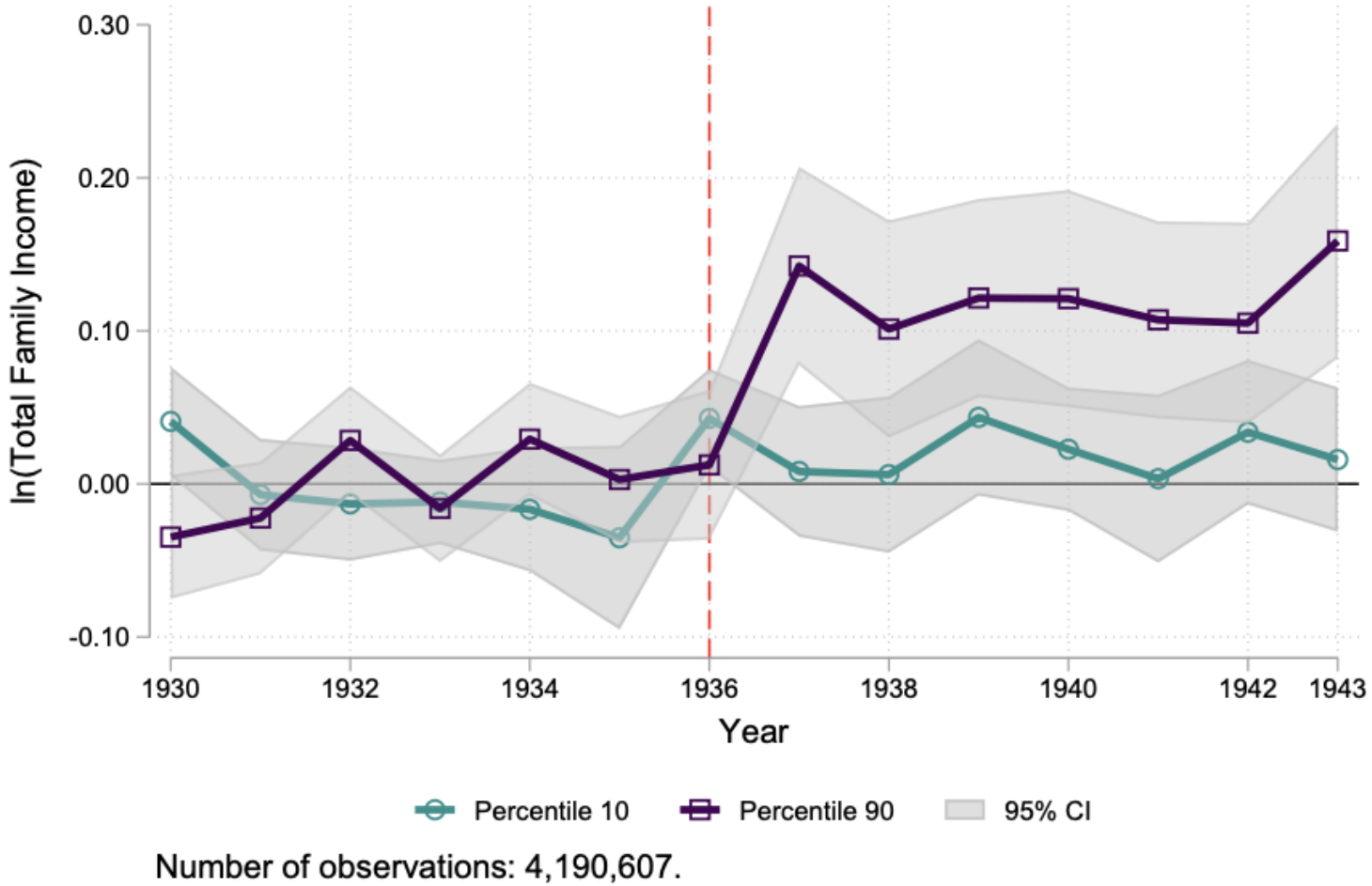


(c) Employment



(d) Work Limiting Disability

Gradients by pharmacist access



Number of observations: 4,190,607.

Additional robustness

- Measurement error in pneumonia mortality
- Fewer controls
- Additional controls (New Deal Era spending, birth state specific trends)
- Removing Dust Bowl states and WWII cohorts
- Selective migration and fertility
- Investigate implicit strong parallel trends assumption in continuous DID models (Callaway et al 2025)

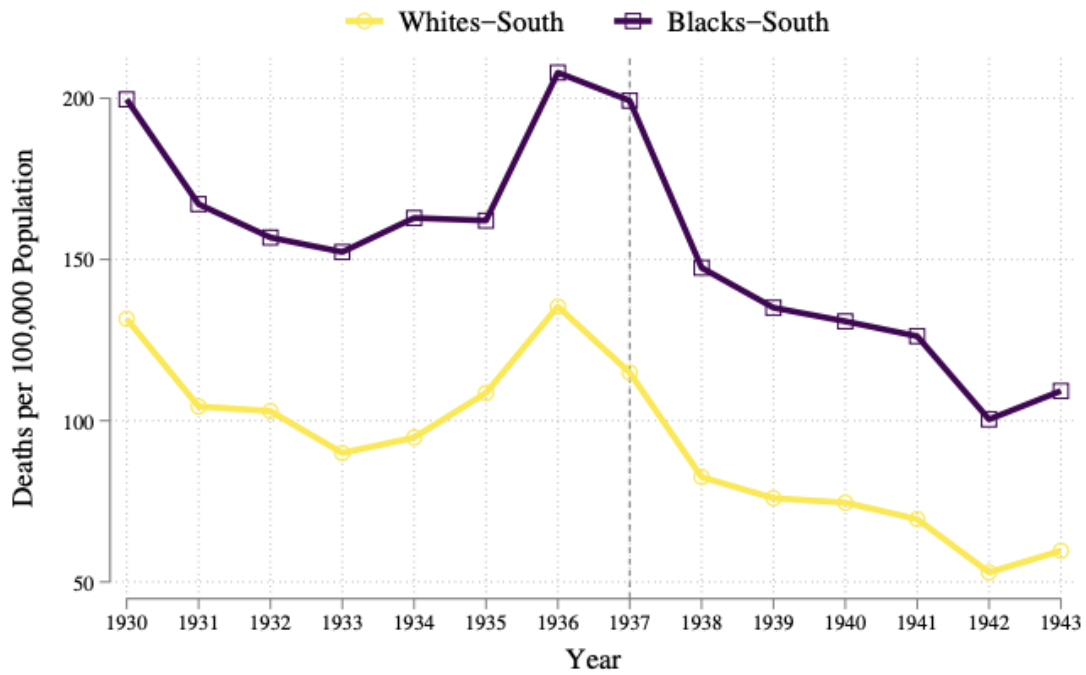
Heterogeneous effects

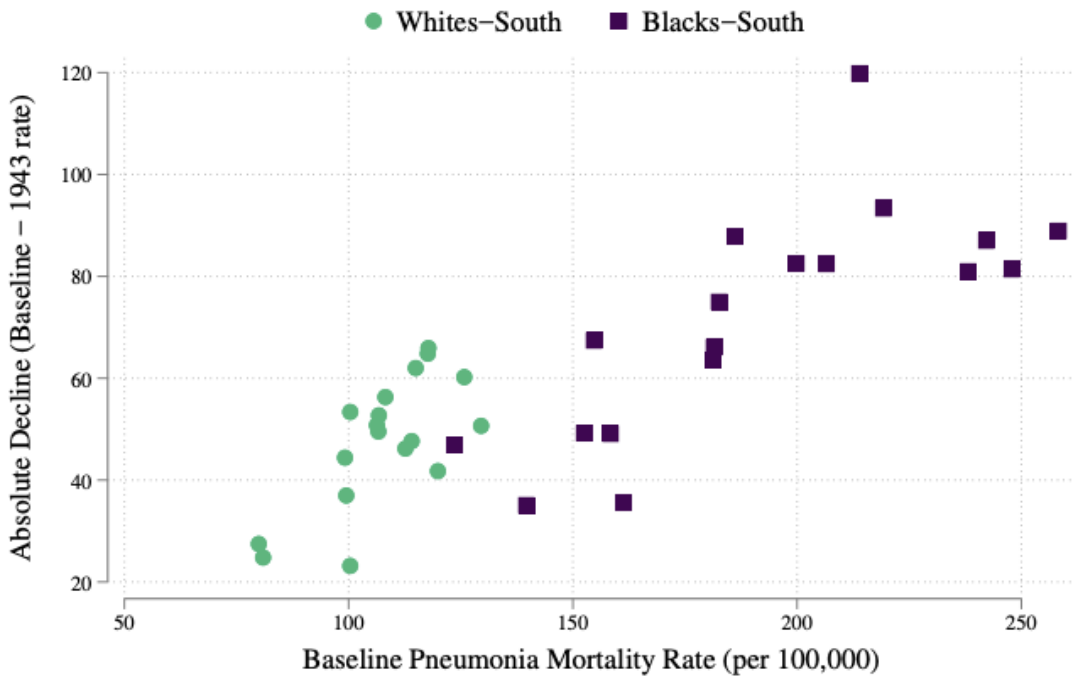
- White men: large positive effects on schooling, family income, disability
- White women: effects generally smaller in magnitude (except employment)
- Black men: large positive effects for family income (concentrated around median) and employment; larger standard errors
- Black women: *negative* estimates for schooling and employment

Why?

- Differential exposure to pneumonia at baseline
- Differential measurement error in exposure
- *Differential access to sulfa drugs* (Jayachandran, Lleras-Muney, Smith et al 2010
- *Barriers to women's participation in the economy* (Goldin 1991)

Access to sulfa drugs





Non-market outcomes for women

	Ever Married	Currently Married	# Children Ever Born	Any Child	# Children | Any Child
Panel A: White Women					
Post Sulfa × Base Exposure	0.0129***	0.0313**	-0.134*	0.00489	-0.148**
	(0.00428)	(0.0120)	(0.0762)	(0.00814)	(0.0695)
FWER p-value	[0.026]	[0.058]	[0.182]	[0.554]	[0.106]
Effect size for an interquartile shift in base exposure	0.364 pp	0.880 pp	-0.0378 children	0.137 pp	-0.0417 children
Observations	665,908	665,908	595,340	595,340	531,715
Panel B: Black Women					
Post Sulfa × Base Exposure	0.0825***	0.0615*	1.217***	0.167***	0.718***
	(0.0230)	(0.0362)	(0.219)	(0.0252)	(0.250)
FWER p-value	[0.028]	[0.144]	[0.002]	[0.001]	[0.054]
Effect size for an interquartile shift in base exposure	2.319 pp	1.729 pp	0.342 children	4.692 pp	0.202 children
Observations	70,087	70,087	62,284	62,284	53,146

Empirical strategy: variation by context

- Systemic discrimination and resulting barriers in education and labor markets → returns to health capital
  - May explain race (x gender) patterns in estimates

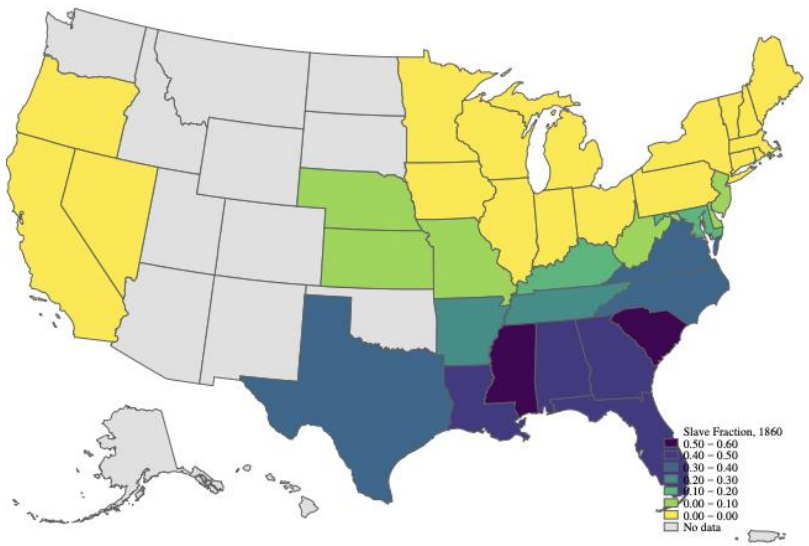
- We assess how returns to sulfa vary by measures of systemic discrimination:

$$Y_{istc} = \beta_0^{rg} + \beta_1^{rg}(\text{Post sulfa}_t \times \text{Base Exposure} \times \text{Discrimination Proxy}_s) + \beta_2^{rg}(\text{Post sulfa}_t \times \text{Base Exposure}_s)$$
$$+\beta_3^{rg}(\text{Post sulfa}_t \times \text{Discrimination Proxy}_s) + \theta_s^{rg} + (\eta_t \times \mu)_d^{rg} + \lambda_c + X_{st}'\Gamma^{rg} + \varepsilon_{istc}^{rg}, \quad (3)$$

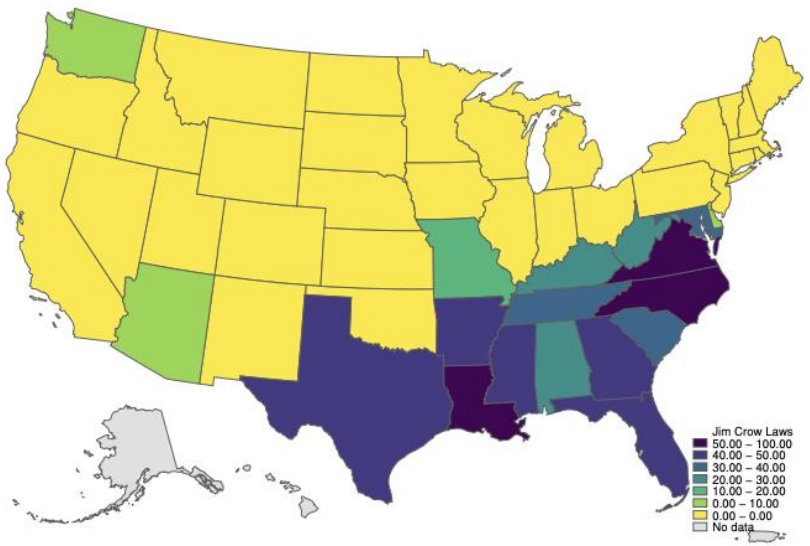
Measures of systemic discrimination

- Enslaved population share in 1960 (Nunn 2008; Acharya et al 2016, etc)

- Number of Jim Crow Laws (Althoff and Reichardt 2024)



(c) Geographical Dispersion of enslaved population



(d) Geographical Dispersion of Jim Crow laws

	Gradient: Historical Fraction of Enslaved People				Gradient: Number of Jim Crow Laws			
	Schooling	log(Family Income)	Employ-ment	Work Limiting Disability	Schooling	log(Family Income)	Employ-ment	Work Limiting Disability
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Black Men								
Post Sulfa × Base Exposure	1.459***	0.327***	0.159***	-0.0750***	0.831**	0.252***	0.185***	-0.0606***
	(0.261)	(0.0756)	(0.0342)	(0.0247)	(0.323)	(0.0503)	(0.0383)	(0.0164)
FWER p-value	[0.019]	[0.073]	[0.072]	[0.129]	[0.062]	[0.018]	[0.019]	[0.049]
Post Sulfa × Base Exposure × Discrimination Proxy	-3.957***	-0.602***	-0.305***	0.238***	-0.0266***	-0.00497***	-0.00387***	0.00229***
	(0.753)	(0.206)	(0.0968)	(0.0643)	(0.00948)	(0.00175)	(0.00107)	(0.000463)
FWER p-value	[0.022]	[0.024]	[0.034]	[0.058]	[0.060]	[0.087]	[0.036]	[0.025]
Effect size at bottom decile of discrimination proxy	0.554 years	11.37 %	5.570 pp	-2.974 pp	0.353 years	9.306 %	6.920 pp	-2.726 pp
Effect size at top decile of discrimination proxy	0.0645 years	3.934 %	1.793 pp	-0.0292 pp	0.0231 years	3.160 %	2.135 pp	0.106 pp
Observations	65,266	161,583	170,601	170,601	66,597	164,497	173,715	173,715
Panel B: Black Women								
Post Sulfa × Base Exposure	0.421	0.0391	-0.00887	-0.109***	-0.229	0.0115	-0.0396	-0.0644**
	(0.294)	(0.0984)	(0.0312)	(0.0374)	(0.320)	(0.0755)	(0.0353)	(0.0275)
FWER p-value	[0.343]	[0.870]	[0.785]	[0.014]	[0.662]	[0.888]	[0.538]	[0.083]
Post Sulfa × Base Exposure × Discrimination Proxy	-3.154***	-0.473*	-0.323***	0.339**	-0.0199**	-0.00301	-0.00107	0.00234**
	(0.819)	(0.257)	(0.0922)	(0.136)	(0.00859)	(0.00240)	(0.000967)	(0.000975)
FWER p-value	[0.001]	[0.0657]	[0.002]	[0.025]	[0.066]	[0.537]	[0.537]	[0.066]
Effect size at bottom decile of discrimination proxy	0.233 years	2.814 %	0.923 pp	-4.304 pp	0.0244 years	1.667 %	-0.636 pp	-2.855 pp
Effect size at top decile of discrimination proxy	-0.157 years	-3.034 %	-3.075 pp	-0.109 pp	-0.222 years	-2.053 %	-1.958 pp	0.0374 pp
Observations	81,074	208,673	215,520	215,520	82,649	212,391	219,355	219,355

Variation by context

- No similar gradients for white men and women
- Gradients cannot be explained by:
  - Differential access to sulfa
  - Selective migration or mortality

Summary

- Medical innovations to treat pneumonia yield significant long-run benefits
  - Modern relevance: pneumonia remains "a neglected global threat" (Lancet Respiratory Medicine 2025)
- Long-run returns to a healthy start depend critically on institutional environments and opportunities afforded
- Results highlight another channel by which the legacies of systemic discrimination persist over time

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