A Gift of Health

The Duke Endowment's Impact on Hospital Care and Mortality

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Introduction

- Structural and financial barriers in access to healthcare remain common in the U.S.
- Can increased supply of hospital care improve infant and prime-age mortality?
  - By attracting better quality staff (physicians and nurses)
  - By removing technological bottlenecks in providing quality healthcare
- Duke Endowment focused on improving access for both Blacks and Whites
  - How did Endowment funding affect mortality by race?

Contributions of this project

Contributions

- Health consequences of increased supply of hospital care
  - Extensive vs. intensive margin
  - Short-run (infant mortality) & long-run (prime-age mortality)
  - Physical and human capital
- Differential effects by race
- Ability to measure "first-stage" relationship
- Complementarity with technological innovation
  - Increase in supply of hospital care
  - Introduction of antibiotics

Main findings

1. Exposure to Duke Endowment financial support lead to:
   - Increases in intensive margin of health care supply
   - Reductions in infant mortality: Twice as large for blacks
   - Suggestive gains in prime-age mortality
2. Reductions in infant mortality can be attributed to increases in supply of nurses and changes in quality of doctors
3. Magnitude of effects are amplified by improvements in medical technology

The Duke Endowment

Historical Background

- The **Duke Endowment** was founded by James Buchanan Duke in 1924 with a $40 million mandate to improve lives of poor in North and South Carolina
  - Strong focus on improved access to healthcare (32%)
  - Auxiliary funding for other beneficiaries included universities (46%), churches (12%), and orphanages (10%)

The advance in the science of medicine growing out of discoveries, such as in the field of bacteriology, chemistry and physicians, and growing out of inventions such as the X-ray apparatus, make hospital facilities essential for obtaining the best results in the practice of medicine and surgery. So worthy do I deem the cause and so great do I deem the need that I very much hope the people will see to it that the adequate and convenient hospitals are assured in their respective communities, with especial reference to those who are unable to defray such expenses of their own.

A historical health care intervention

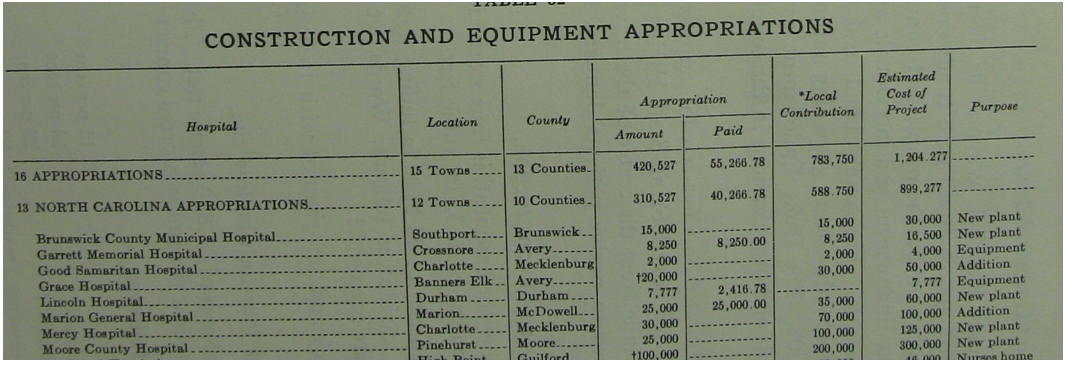
Historical Background

- The Duke Endowment's **Hospital Section** funded capital and operating expenditures of hospitals
  - Constructed new hospitals
  - Expanded and improved equipment in existing hospitals
- The Endowment also subsidized free care by contributing $1.00 per charity patient per day (one-third of average daily cost of patient care)
- By 1940, it contributed over $1 million annually in the Carolinas

Data sources

- Annual reports of the Duke Endowment Hospital Section
  - Capital appropriations for hospital funding
- Hospitals registered by the American Medical Association
- Individual North Carolina death certificates
  - We assign treatment based on place of birth
  - Locations at time of death are potentially endogenous
- Social Security Administration NUMIDENT Data (2007 version)
  - Individual-level records with date and county of birth
  - Allows for observing probability of survival up to 65
- Doctors listed in American Medical Directory

Raw data: Annual report from hospital section of Duke Endowment



CONSTRUCTION AND EQUIPMENT APPROPRIATIONS

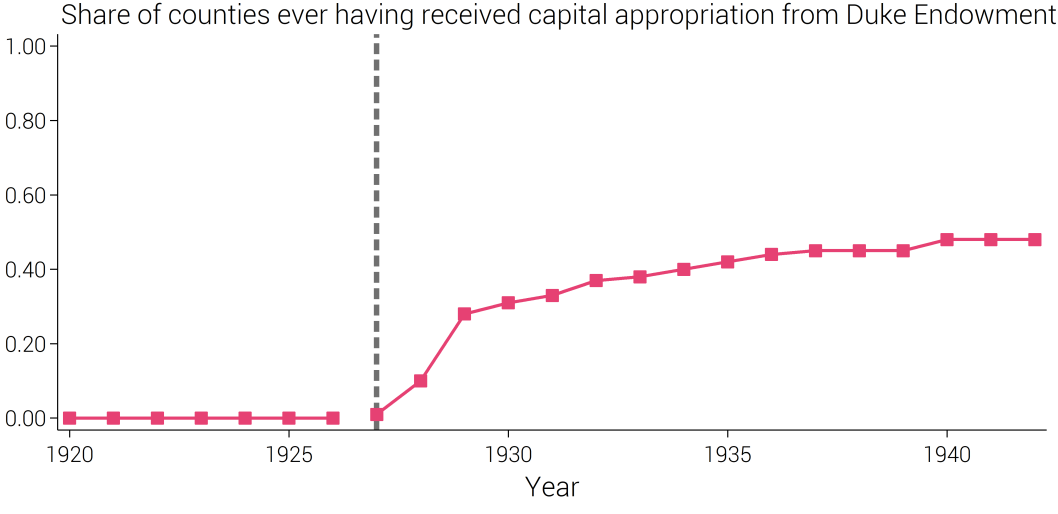
Hospital	Location	County	Appropriation		*Local Contribution	Estimated Cost of Project	Purpose
			Amount	Paid			
16 APPROPRIATIONS	15 Towns	13 Counties	420,527	55,266.78	783,750	1,204,277	
13 NORTH CAROLINA APPROPRIATIONS	12 Towns	10 Counties	310,527	40,266.78	588,750	899,277	
Brunswick County Municipal Hospital	Southport	Brunswick	15,000		15,000	30,000	New plant
Garrett Memorial Hospital	Crossnore	Avery	8,250	8,250.00	8,250	16,500	New plant
Good Samaritan Hospital	Charlotte	Mecklenburg	2,000		2,000	4,000	Equipment
Grace Hospital	Banners Elk	Avery	†20,000		30,000	50,000	Addition
Lincoln Hospital	Durham	Durham	7,777	2,416.78		7,777	Equipment
Marion General Hospital	Marion	McDowell	25,000	25,000.00	35,000	60,000	New plant
Mercy Hospital	Charlotte	Mecklenburg	30,000		70,000	100,000	Addition
Moore County Hospital	Pinehurst	Moore	25,000		100,000	125,000	New plant
		Guilford	†100,000		200,000	300,000	New plant
							Nurses home

Empirical specification

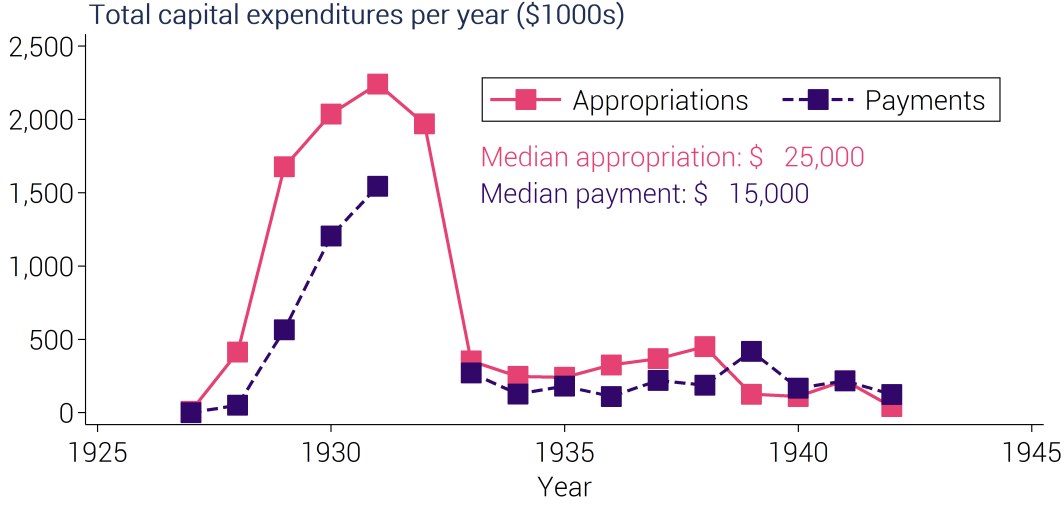
Estimation strategy

- Estimate effect of hospital funding from Duke Endowment between 1920 and 1942 on:
  - Supply of hospital beds (extensive vs. intensive margin)
  - Infant mortality and mortality at ages 20 to 65 (overall and by race)
- Difference-in-differences with staggered timing
  - First difference: Before vs. after first capital appropriation in a county (time variation)
  - Second difference: Affected vs. unaffected counties (spatial variation)
- Capital expenditures: Intention-to-treat interpretation
  - First appropriation vs. actual payments: Not all appropriated funds paid out
  - Captures non-facility treatment effects (i.e., change in accounting practices)

Expansion in financial support from Duke Endowment



Intensive margin of Duke Endowment funding



Empirical specification

Estimation strategy

- Two-way fixed effects equation

$$Y_{ct} = \alpha_0 + \alpha_1(\text{First capital appropriation}_{ct}) + \gamma_c + \delta_t + \mathbf{\Theta X_{ct}} + \epsilon_{ct} \quad (1)$$

- Event-study design

$$\begin{aligned} Y_{ct} &= \alpha_0 + \sum_{j=-7}^{-2} \beta_j(\text{First capital appropriation}_{ct}) \\ &+ \sum_{j=0}^{7} \beta_j(\text{First capital appropriation}_{ct}) + \gamma_c + \delta_t + \mathbf{\Theta X_{ct}} + \epsilon_{ct} \end{aligned} \quad (2)$$

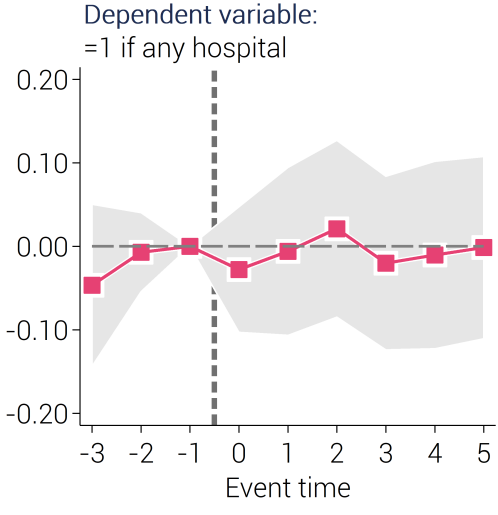
First stage

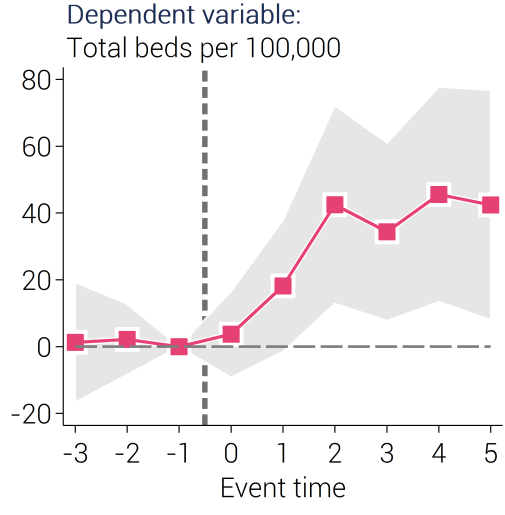
Did Duke Endowment funding improve access to hospital care?

On the extensive margin? Or intensive margin?

Event study results for hospital access

First stage



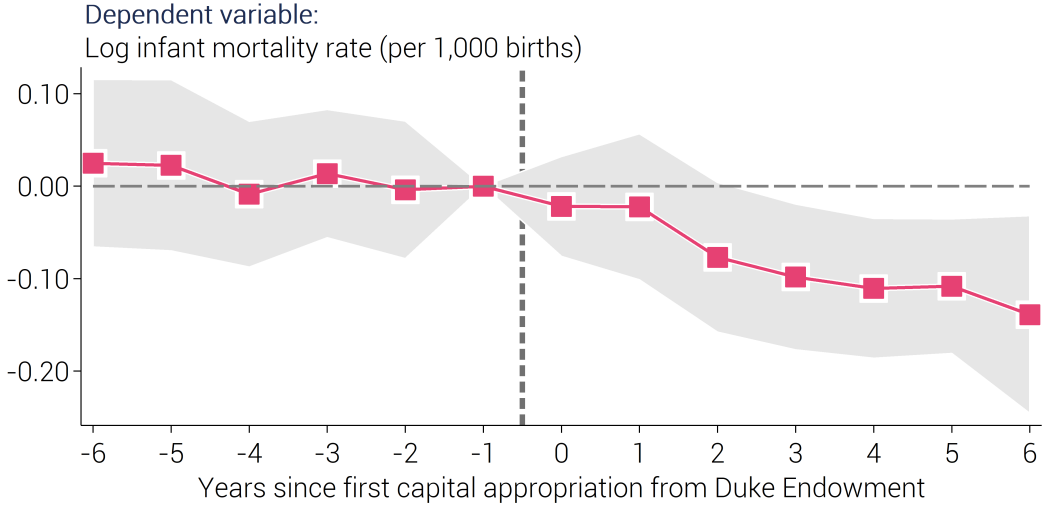


Main results: Effects on mortality

Did counties receiving financial support from Duke Endowment experience a decline in mortality?

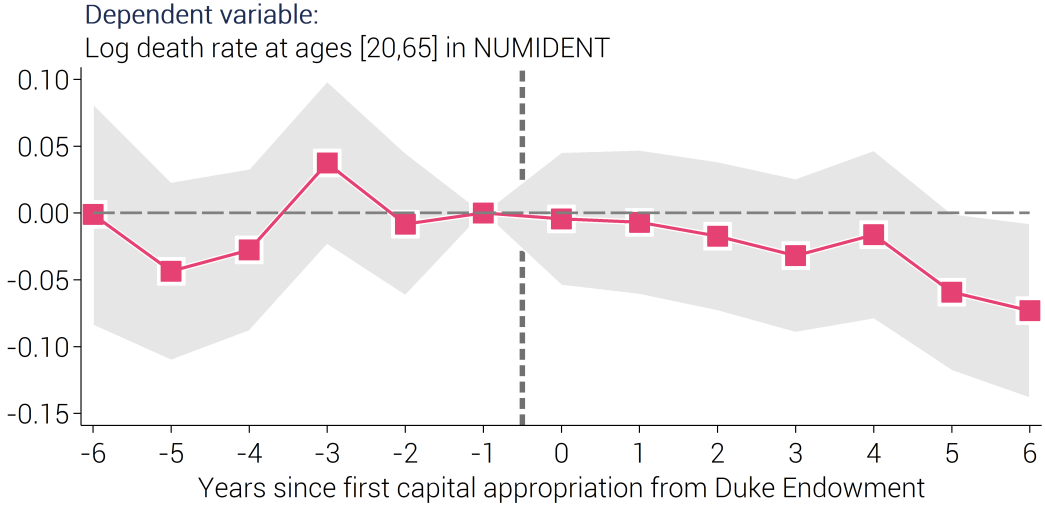
Event study results for infant mortality

Mortality



Event study results for deaths at ages 20 to 65

Mortality



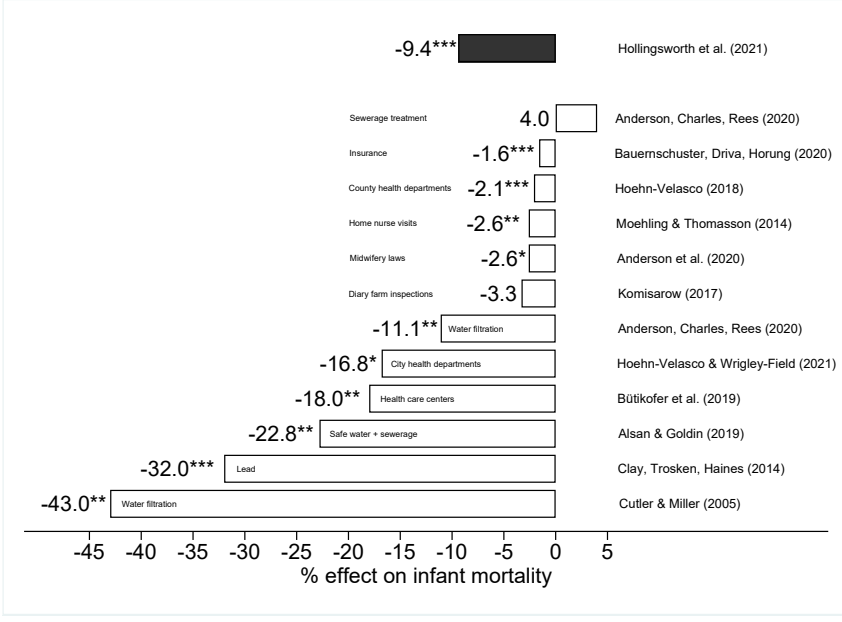
Effects on mortality

Results

	Ln(infant mortality)		Ln(mortality at 20 to 65)	
	(1)	(2)	(3)	(4)
=1 if Duke exposure	-0.104***	-0.094***	-0.043***	-0.034**
	(0.031)	(0.030)	(0.016)	(0.015)
N	2,300	2,300	2,300	2,300
Controls	No	Yes	No	Yes

Comparison with other studies

Results



Effects on mortality by race

Results

	Ln(infant mortality)				Ln(mortality at 20 to 65)			
	(1) All	(2) Pooled	(3) White	(4) Black	(5) All	(6) Pooled	(7) White	(8) Black
=1 if Duke exposure	-0.086***	-0.079***	-0.061**	-0.134***	-0.014	-0.014	-0.005	-0.014
	(0.026)	(0.027)	(0.028)	(0.046)	(0.014)	(0.014)	(0.020)	(0.021)
N	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000

Event study estimates | Estimating adjusted birth cohort size by race

- Note: Goodman-Bacon (2018) finds effects of Medicaid on Nonwhites only. Anderson, Charles, Rees (2021) do not find effects of hospital desegregation on either Blacks or Whites but Almond, Chay, Greenstone (2006) do.

Mechanisms

Did hospitals supported by the Duke Endowment attract more doctors? What about nurses?

Were the doctors of higher quality?

Does the type of spending matter?

Effects on number of doctors and nurses per 100,000 population

Mechanisms

			Doctors			
	Nurses		IPUMS		AMD	
	(1)	(2)	(3)	(4)	(5)	(6)
=1 if Duke exposure	62.057***	40.210***	-3.019	-4.642	3.160	2.441
	(14.847)	(13.777)	(3.966)	(3.631)	(4.048)	(3.081)
N	388	388	388	388	700	700
Controls	No	Yes	No	Yes	No	Yes

Data sources

Effects on quality of doctors per 100,000 population

Mechanisms

	Young		Old		High quality		Low quality	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
=1 if Duke exposure	11.428***	7.451**	-8.135***	-4.931**	8.772***	6.953***	-7.609***	-5.575***
	(4.219)	(3.152)	(2.727)	(2.084)	(2.548)	(2.136)	(1.773)	(1.422)
N	700	700	700	700	700	700	700	700
Controls	No	Yes	No	Yes	No	Yes	No	Yes

Heterogeneity by type of funding

Heterogeneity

	Log infant mortality rate per 1,000 births				
	(1)	(2)	(3)	(4)	(5)
=1 if new hospital	-0.043				-0.038
	(0.047)				(0.041)
=1 if addition to hospital		-0.184***			-0.182***
		(0.048)			(0.053)
=1 if equipment			-0.055		-0.007
			(0.049)		(0.045)
=1 if hospital purchases				-0.006	0.014
				(0.084)	(0.057)
N	2,300	2,300	2,300	2,300	2,300

Mechanisms

Was the impact of Duke Endowment funding amplified by the availability of modern antibiotics?

Interaction with sulfa

Empirical specification

- Difference-in-difference in:
  - Access to Duke endowment
  - Access to Sulfa drugs
- Estimating equation for interaction effects

$$
\begin{aligned}
Y_{ct} = {} & \alpha_0 + \alpha_1(\text{First capital expenditures}_{ct}) * (\text{Sulfa}_{ct}) \\
& + \alpha_2(\text{First capital expenditures}_{ct}) \\
& + \alpha_3(\text{Sulfa}_{ct}) + \gamma_c + \delta_t + \boldsymbol{\Theta}\mathbf{X_{ct}} + \epsilon_{ct}
\end{aligned}
$$

- Assumptions
  - Duke endowment and Sulfa access are as good as random
  - Access to Duke endowment orthogonal to Sulfa adaptation

Interaction with sulfa

Results

	Ln(infant mortality)		Ln(mortality at 20 to 65)	
	(1)	(2)	(3)	(4)
=1 if Duke exposure	-0.082***	-0.073***	-0.034**	-0.025*
	(0.026)	(0.027)	(0.015)	(0.015)
Duke exposure × sulfa	-0.058	-0.056	-0.024	-0.023
	(0.055)	(0.050)	(0.018)	(0.018)
N	2,300	2,300	2,300	2,300
Controls	No	Yes	No	Yes

Robustness

- Event study specification choices
  - No binning of endpoints
  - Changing panel length
- Goodman-Bacon (2021) decomposition
  - Total weight on treated vs. untreated comparisons: 0.824 Summary table
- Alternate event study estimators
  - Callaway and Sant'Anna (2021) Effects on mortality IMR by race
  - Stacked regression (Cengiz et al. 2019) Effects on mortality
- Functional form and weighting Logs and levels

Conclusions

- Evidence that increased supply of hospital care improves mortality outcomes
  - Driven by intensive rather than extensive margin increases
  - Understudied question outside of insurance/public health interventions context
  - Modest financial spending so potentially encouraging ROI
  - Less clear-cut effects on prime-age mortality
- Mechanisms
  - Plausibly improved working conditions attracted more nurses and higher quality doctors
  - Compounding role of technological change in gains from health care

Thank you!

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