Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

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Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Motivation

- Childhood health can have significant effects on human capital formation.
- By influencing educational investment, even short term health shocks can have long term consequences.
- The improvements in childhood health in the early 20th century may have driven growth of the human capital stock.
- This paper uses unique early 20th century sibling data to demonstrate that poor childhood health led to poor educational attainment outcomes both across and within households.

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Brief Overview of Paper

- World War II enlistment records are linked to the federal census and brothers are matched together to create a micro-level panel dataset with health, education and household characteristics for each individual.
- These data reveal that trends in educational attainment over time closely tracked trends in average height for all regions of the United States.
- Differences in average height and educational attainment were highly correlated with differences in childhood disease environment across cities and states.
- Differences in heights between brothers predict substantial differences in educational attainment: one inch of height lost due to disease leads to as much as half a year less schooling.

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Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment



US school enrollment rates and life expectancy, 1850-1998

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3

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Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment



US high school graduation rates and infant mortality rates, 1850-1998 Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

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Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment



School enrollment rates and life expectancy by country for the year 2000 (blue points) and by decade for the US (red points)

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John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment



School enrollment rates and infant mortality rates by country for the year 2000 (blue points) and by decade for the US (red points)

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3

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Previous Studies of Health and Human Capital

The modern relationship between health and education:

- Two common approaches to solving endogeneity problem: twin/sibling studies and instrumenting for health using exogenous shocks
- Twin/sibling studies: Behrman and Rosenzweig (2004), Royer (2005), Currie and Moretti (2007), Oreopoulos et al. (2006), Black, Devereux and Salvanes (2007)
- Instrumenting for health: Almond, Edlund and Palme (2007), Nilsson (2008)
- Studies generally find positive correlations between childhood health and cognitive ability, educational attainment, labor market outcomes

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Previous Studies of Health and Human Capital

The historical relationship between health and education:

- Sibling and twin studies haven't been an option with historical data
- Alternative is to look for natural experiments typically related to disease environment
- Bleakley (2007): hookworm eradication
- Bleakley (2010), Lucas (2010): malaria eradication
- Almond (2006): outcomes of individuals in utero during influenza pandemic

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John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Empirical Approach

- Use micro-level health and education data to apply sibling study methods to historical data
- WWII enlistment records provide a source of education and health information
- Linking enlistment records to census records allows for identification of brothers and provides information on childhood household environment
- Use differences in heights between brothers as a proxy for differences in childhood health to assess effects of health on educational attainment

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John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

World War II Enlistment Records



- Roughly 9,000,000 records
- Records include: name, birth date, year of enlistment, birth state, county of residence, years of education, civilian occupation, race, height, weight
- Offers a (somewhat) nationally representative sample of males
- Ages of enlistees and years of enlistment lead to sizable number of observations for cohorts born between 1897 and 1923

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John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Federal Census Records

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- Household and sibling data will come from the 1930 federal census
- For an enlistee, the census will provide birth order relative to all siblings and relative to brothers
- For the enlistee's parents, the census will provide age, occupation, birthplace, value of house, and literacy

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Step 1: Dropping enlistees with incomplete or implausible data reported

- 1.5 million enlistees do not have state and county of residence information
- 200,000 enlistees do not report birth state
- 2.6 million enlistees do not report height and weight information
- 200,000 enlistees have heights and weights that correspond to an implausible body mass index (starvation or hyper-obesity)
- This leaves roughly 4 million records

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John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Step 2: Identifying potential brothers

- Enlistees are sorted by last name, state and county of residence, birth state and age
- Sets of potential brothers are identified as individuals with the same last name, state and county of residence and birth state and a difference in age of no more than two years
- This results in roughly 1,500,000 potential brothers
- The sets of brothers are sorted by last name and then a ten percent sample of the sets is taken

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John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Step 3: Searching census records (automated steps)

- A perl script is used to search an online database of census records for each potential brother using name, birth year and birth state as the search criteria
- The top search result is extracted from the results and the town of residence and parents' names are written to the file of enlistees
- Within a set of potential brothers, only individuals with the same town of residence and parents' names from the census are kept (roughly 65% of the potential brothers get dropped)

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John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Step 4: Searching census records (manual steps)

- The original census search results are brought up and inspected one individual at a time
- The match is confirmed if the name matches, the state matches, the birth year in the census is within one year of the birthyear in the enlistment records and there are no other individuals in the census meeting those criteria
- If two potential brothers are both confirmed as correct and unique matches, the image of the original census page is retrieved to confirm that they were living in the same household
- Roughly 90% of the individuals surviving the automated census matching get dropped in this stage

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John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Step 5: Recording household information

- For the remaining brothers, household characteristics are transcribed from the census manuscripts
- Information includes family size, birth order, birth order among brothers, house value (or monthly rent), parents' names, birthplaces, ages, literacy and occupations

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Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educationa Attainment

Conclusions

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Sample Selection Bias

The way in which the dataset is constructed raises several potential sample selection problems:

- Enlistees as a group may not be representative of the population
 - Enlistees could be rejected on the basis of height and weight, defective teeth, poor vision, deafness, venereal disease and other conditions
 - Enlistees could be rejected for being illiterate
 - More educated men may have been more likely to avoid the war
- Successfully matched enlistees may differ from enlistees with no matches (or multiple matches)
- Successfully paired brothers will tend to be from larger families

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John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Issues with the Measurement of Education

- The reported educational attainment is in terms of years of secondary and postsecondary education
- 26% of the enlistees did not complete any secondary or postseconday schooling
- This censoring also creates problems with racial disparities in education (60% of black enlistees have no education beyond grammar school)
- Reported education may not represent the final level of education achieved (just as there is catch-up growth, there could be catch-up schooling)

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Summary Statistics for the Brother Pairs

Summary statistics for the sar	Summing statistics for the sample of matched brother pairs											
	Sample broth	of matched er pairs	$\mathbf{Population}^{\dagger}$									
		Standard		Standard								
Variable	Mean	deviation	Mean	deviation								
Individual characteristics:												
Height (inches)	68.10	2.74	68.30	2.78								
Weight (pounds)	147.88	21.03	150.03	22.50								
Years of secondary and postsecondary education	2.42	1.94	2.76	2.22								
Age	22.16	2.43	22.44	3.45								
Household characteristics:												
Father's log income	3.08	0.37	3.12	0.43								
Number of siblings	5.14	2.18	2.58	1.74								
Number of brothers	3.63	1.46	1.38	1.25								

Summary statistics for the sample of matched brother pairs

[†]Population is defined as all potential brothers in the enlistment records for the individual characteristics and all households in a 1% sample of the 1930 census with at least one child for the household characteristics. Father's income is measured in hundreds of 1950 dollars.

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Summary Statistics for the Brother Pairs

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	Mean	Standard deviation							
Difference in height	-0.13	2.82							
Difference in weight	-2.59	23.18							
Difference in educational attainment	-0.01	1.72							
Magnitude of difference in height	2.11	1.89							
Magnitude of difference in weight	17.34	15.60							
Magnitude of difference in educational attainment	1.13	1.30							
Difference in age	1.24	2.26							
Difference in birth order among siblings	1.22	0.55							
Correlation between heights	C).47							
Correlation between weights	C	0.35							
Correlation between educational attainments	C).61							

Differences between metched brothers

All differences are defined as the younger brother's value minus the older brother's.

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Conclusions

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Distribution of Educational Attainment



Distribution of educational attainment for matched brothers and males in their 20s in the 1940 federal census Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

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Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Conclusions

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Distribution of Heights



Height distributions for veterans of World War II and non-veterans, 1976

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John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Conclusions

Height and Education Over Time



Mean height and educational attainment by cohort, 1893-1923

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Conclusions

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Height and Education Over Time



Mean height and educational attainment by cohort and region

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John Parman University of California - Davis

Introductior

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Conclusions

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Height and Education Across Counties



Mean height by county for World War II enlistees

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Conclusions

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Height and Education Across Counties



Mean years of secondary and post-secondary education by county for World War II enlistees Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Conclusions

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Height as a Product of Childhood Health

- Height will serve as a proxy for childhood health
- The alternatives are weight or body mass index (both of which are influenced by adult behaviors)
- There is little doubt that height is a function of net nutrition during childhood
- It is less clear that height can pick up childhood health variation within a household
- Disease is the most likely source of this type of variation

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Disease Environment Data

- City and state level disease data offer a way to check that disease rates do correlate with heights
- Data come from census mortality statistics (Grant Miller's data) and from Public Health Reports (city level mortality and morbidity data)
- Data on cerebrospinal fever, chicken pox, dengue fever, diphtheria, influenza, lethargic encephalitis, malaria, measles, mumps, pellagra, pneumonia, polio, scarlet fever, septic sore throat, smallpox, tuberculosis, typhoid fever and typhus
- Diseases will be divided by the age groups they target

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Age distribution of cases and fatalities by disease											
	Cases	reported i ce	n the 1880 fe nsus	ederal	Deaths reported in statistics, 1	federal mortality 921-1925					
	Mean	Median			% of deaths under 2	% of deaths under					
Disease	age	age	Skewness	Cases	years old	10 years old					
Diabetes	49.7	54	-0.45	35	0.33%	2.33%					
Nephritis	48.1	50	-0.27	619	0.74	1.82					
Circulatory disease	42.0	43	0.02	591	0.68	1.72					
Diarrhea	31.9	30.5	0.2	210							
Smallpox	26.8	30	0.27	19	11.60	18.10					
Influenza	33.8	32	0.27	301	17.92	24.95					
Pneumonia	35.7	34	0.28	253	40.10	48.31					
Typhus	29.0	30	0.43	9	0.00	6.25					
Tuberculosis	35.2	32	0.45	2389	3.25	6.46					
Malaria	30.4	28	0.53	917	15.84	34.09					
Meningitis	29.2	21	0.73	13	36.28	59.87					
Typhoid	26.5	22	0.92	313	1.72	12.05					
Mumps	18.9	14.5	1.58	60	22.57	52.60					
Diphtheria	16.8	13	1.59	123	20.03	85.60					
Scarlet fever	9.3	6	1.67	143	13.86	72.48					
Measles	10.7	8	1.82	1184	55.35	87.16					
Chicken pox	12.1	7	2.12	16							
Whooping cough	5.8	4	4.71	338	82.26	98.97					

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

fitual fates of discuse includince at the city and state it for										
	Deaths per 100,000 people (state level)	Deaths per 100,000 people (city level)	Cases per 1,000 people (city level)	Correlation between deaths and cases (city level)						
From diseases targeting	51.21	11.54	9.22	0.08						
infants	(25.96)	(7.99)	(5.23)							
From diseases targeting	20.87	9.37	2.94	0.22						
older children	(11.08)	(5.77)	(1.35)							
From diseases targeting	419.01	7.18	0.65	0.45						
adults	(82.22)	(6.91)	(0.70)							

Mean rates of disease incidence at the city and state level

Standard deviations are given in parentheses. The state level figures include data for 47 states (data are not available for Alaska, Hawaii and Nevada). The city level figures include data for the 74 largest cities. Note that the sets of diseases differ between the state and city level data so the means cannot be directly compared. Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment



Mean height plotted against mortality rates for states

Childhood Health and Human Capital: New Evidence from Genetic Brothers in <u>Arms</u>

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Conclusions

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Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Conclusions

Mean rates for mortality due to infant diseases by state

Colored by quintile of the infant disease mortality rate distribution. Darker colors indicate lower mortality rates.



Mean height by state

Colored by quintile of the height distribution. Darker colors indicate taller heights.

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

ntroduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Conclusions

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	City level dise per 1,00	ase data, cases 0 people	State level of deaths per 10	lisease data, 00,000 people
	(1)	(2)	(3)	(4)
Diseases targeting	-0.005***		-0.012***	
infants	(0.001)		(0.000)	
Diseases targeting	-0.012***		-0.002***	
older children	(0.003)		(0.000)	
Diseases targeting		-0.006***		-0.010***
all children		(0.001)		(0.000)
Diseases targeting	0.156***	0.157***	-0.001***	-0.001***
adults	(0.006)	(0.006)	(0.000)	(0.000)
Region dummies:				
Northeast	-0.512***	-0.514***	-0.012*	0.012*
	(0.006)	(0.006)	(0.007)	(0.007)
South	0.165***	0.165***	0.113***	0.040***
	(0.011)	(0.011)	(0.005)	(0.005)
West	0.377***	0.374***	0.269***	0.232***
	(0.008)	(0.008)	(0.007)	(0.007)
Constant	70.146***	70.139***	68.527***	68.600***
	(0.714)	(0.715)	(0.556)	(0.561)
Observations	1,289,257	1,289,257	3,042,439	3,042,439
R-squared	0.03	0.03	0.03	0.03

Marginal effects of disease environment on stature, height (in inches) as the dependent variable.

Robust standard errors in parentheses. Omitted region is the Midwest. All regressions control for race and a quadratic in age. * significant at 10%; ** significant at 5%; *** significant at 1% Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Estimating the Relationship Between Height and Education

Two approaches to estimating the effect of height on education:

- Regressing educational attainment on height, personal characteristics, household characteristics
 - Omitted variable bias due to unobserved household characteristics
 - Solve this problem by first differencing the data: regress difference in brothers' education on difference in heights
- Logit regression with high school completion as dependent variable
 - Can't use first difference approach to handle omitted variable bias
 - Can use family fixed effects with a conditional logit specification

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Basic Height and Education Regressions

secondary	and postseco	ndary educ	cation as th	e depender	ıt variable.	
	(1)	(2)	(3)	(4)	(5)	(6)
Height (inches)	0.064***	0.063***	0.051***	0.070***	0.069***	0.061***
	(0.010)	(0.010)	(0.013)	(0.010)	(0.011)	(0.013)
Number of siblings	-0.251***	-0.220***	-0.265***			
	(0.020)	(0.021)	(0.026)			
Birth order among	0.087***	0.068***	0.092***			
all siblings	(0.024)	(0.026)	(0.033)			
Number of brothers				-0.291***	-0.251***	-0.280***
				(0.027)	(0.028)	(0.035)
Birth order among				0.069**	0.062*	0.059
brothers				(0.032)	(0.034)	(0.043)
Ln(father's income)		1.041***	1.069***		1.074***	1.077***
		(0.084)	(0.104)		(0.085)	(0.107)
Father's literacy			0.386***			0.459***
(literate=1)			(0.143)			(0.142)
Mother's literacy			-0.096			-0.080
(literate=1)			(0.158)			(0.160)
Observations	4396	3845	2428	4376	3827	2410
R-squared	0.16	0.20	0.24	0.15	0.18	0.22

OLS estimates of the marginal effects of height on educational attainment, years of secondary and postsecondary education as the dependent variable.

Robust standard errors in parentheses. All regressions control for race, birth state and a quadratic in age. Only individuals who have completed their educational careers are included in the regression sample.

* significant at 10%; ** significant at 5%; *** significant at 1%

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Basic Height and Education Regressions

0 0					2		
Dependent variable:	Attended at lea high schoo	ast one year of ol (yes=1)	High scho (yes	ol graduate s=1)	Attended at least one year of college (yes=1)		
	(1)	(2)	(3)	(4)	(5)	(6)	
Height (inches)	0.056***	0.042**	0.086***	0.081***	0.080***	0.079***	
	(0.013)	(0.019)	(0.013)	(0.019)	(0.026)	(0.029)	
Number of siblings	-0.243***	-0.262***	-0.248***	-0.281***	-0.318***	-0.320***	
	(0.025)	(0.036)	(0.024)	(0.033)	(0.055)	(0.059)	
Birth order	0.083***	0.063	0.070**	0.075*	0.107	0.161**	
among siblings	(0.029)	(0.043)	(0.029)	(0.041)	(0.071)	(0.077)	
Ln(father's income)		1.343***		0.908***		1.031***	
		(0.154)		(0.127)		(0.213)	
Father's literacy		0.097		0.766***		0.887	
(literate=1)		(0.207)		(0.245)		(0.660)	
Mother's literacy		-0.287		0.062		0.314	
(literate=1)		(0.242)		(0.247)		(0.570)	
Observations	4384	2402	4382	2403	2565	2297	

Logit regressions of educational outcomes on personal and family characteristics.

Robust standard errors in parentheses. All regressions include controls for race and birthstate and a quadratic in age. Only individuals who have completed their educational careers are included in the regression sample.

* significant at 10%; ** significant at 5%; *** significant at 1%

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Conclusions

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First Difference Regressions

	(1)	(2)	(3)	(4)	(5)
Race and state controls included:	no	no	no	yes	yes
Difference in height (inches)	0.028*	0.028*	0.027*	0.031**	0.030**
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Number of siblings		0.066***		0.067***	
		(0.019)		(0.020)	
Number of brothers			0.046*		0.045
			(0.028)		(0.029)
Constant	0.075	-0.254**	-0.093	-0.322	-0.146
	(0.066)	(0.108)	(0.116)	(0.338)	(0.353)
Observations	1875	1875	1875	1851	1851
R-squared	0.01	0.01	0.01	0.04	0.03

First difference regressions, difference in years of educational attainment as dependent variable.

Robust standard errors in parentheses. All variables are defined as the younger brother's value minus the older brother's. All regressions control for the difference in age and the difference in age-squared between brothers.

* significant at 10%; ** significant at 5%; *** significant at 1%

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Interpreting the Height Coefficient

 Think of the difference in heights, ΔH, as a measure of differences in height due to health, ΔH*, plus measurement error

$$\Delta H = \Delta H^* + \nu$$

There is an attenuation bias given by:

$$\frac{\sigma_{\Delta H^*}^2}{\sigma_{\Delta H^*}^2 + \sigma_{\nu}^2}$$

- Overall $\sigma^2_{\Delta H}$ in the data is 8 ${\rm in}^2$
- One way to think about σ²_{ΔH*} is Voth and Leunig's (1996) smallpox results (smallpox led to one inch of stunting)

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

First Difference Regressions: Health vs Height Discrimination

educational attainment as dependent variable.									
		I	Deaths per 1,00	0 people due to	:				
Mortality rate measure:	none	infant diseases	childhood diseases	adult diseases	all diseases				
	(1)	(2)	(3)	(4)	(5)				
Difference in height (inches)	0.031**	-0.022	-0.031	-0.181*	-0.148*				
	(0.015)	(0.036)	(0.037)	(0.094)	(0.079)				
Difference in height (inches)		0.082	0.067	0.047**	0.033**				
x Mortality Rate		(0.059)	(0.041)	(0.021)	(0.015)				
Observations	1851	1790	1790	1790	1790				
R-squared	0.04	0.04	0.04	0.04	0.04				
Marginal effect of a one inch of	lifference in	height:							
Evaluated at the mean		0.040	0 020	0 020	0 020				
Evaluated at one standard		0.040	0.030	0.030	0.030				
deviation above mean									
mortality rate		0.062	0.052	0.065	0.063				

First difference regressions with disease environment interactions, difference in years of

Robust standard errors in parentheses. All variables are defined as the younger brother's value minus the older brother's. All regressions control for the difference in age, difference in age-squared, family size, race and state.

* significant at 10%; ** significant at 5%; *** significant at 1%

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Height and Educational Attainment

Conditional Logit Regressions

	families.										
Dependent variable:	Attended at least one year of high school (yes=1)		High scho (yes	ol graduate s=1)	Attended at least one year of college (yes=1)						
	(1)	(2)	(3)	(4)	(5)	(6)					
Height (inches)	-0.016	-0.009	0.066**	0.076**	0.009	-0.000					
	(0.030)	(0.030)	(0.033)	(0.035)	(0.057)	(0.058)					
Age	0.240	0.280	1.692***	1.874***	1.776**	1.668*					
	(0.351)	(0.366)	(0.441)	(0.468)	(0.825)	(0.889)					
Age^2	-0.007	-0.008	-0.035***	-0.038***	-0.032*	-0.030*					
	(0.008)	(0.008)	(0.009)	(0.010)	(0.016)	(0.017)					
Birth order	0.073		0.039		0.149						
among siblings	(0.112)		(0.109)		(0.277)						
Birth order		0.027		0.114		0.067					
among brothers		(0.133)		(0.127)		(0.316)					
Observations	942	938	965	947	256	255					

Conditional logit estimates of the effects of height on educational outcomes within families.

Robust standard errors in parentheses. Regression sample consists only of those brother pairs for which the outcome variable differs across brothers. * significant at 10%; ** significant at 5%; *** significant at 1%

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Summary of Results

- Health (proxied by height) and educational attainment rose substantially from the 1890s to the 1920s
- Substantial variation existed in heights across cities and states, much of which can be explained by differences in the prevalence of disease
- Taller individuals had significantly higher educational attainments than shorter individuals, even after controlling for parental income, parental literacy, family size and birth order
- This relationship holds even after controlling for unobserved family and environmental characteristics by looking at differences between brothers

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment

Future Work

- Incorporate lifespan information by linking to Social Security death index and Veterans Affairs records
- Take advantage of the occupation information in the enlistee records
- Focus on ways in which family structure and local labor markets influenced educational attainment
- Look at racial disparities in health and how health maps into educational and occupational outcomes

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Implications for intergenerational mobility

Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms

John Parman University of California - Davis

Introduction

Childhood Health and Human Capital

Data and Methodology

Height and Disease Environment

Height and Educational Attainment