Health

1. Health Seeking Behaviour: Some Striking Facts

- Achieving a minimum nutrition standard is fairly cheap (even with today's prices).
  - Using price data from the Philippines, Banerjee and Duflo (*Poor Economics*, page 26) calculated the cost of the cheapest diet sufficient to give 2,400 calories,
    - including 10% calories from protein and 15% from fat.
  - It would cost only 21 cents at PPP, very affordable even for someone living on 99 cents a day.
- Yet, there is plenty of malnutrition, even outside countries that face particularly acute food crises.

- The following Table 1 from Banerjee, Deaton and Duflo (AER, 2004) shows some selected health indicators from their survey in Udaipur, Rajasthan.
  - Health status is poor.
  - Nutritional status:
    - Height and weight: 88% of women, and 93% of men, have Body Max Index below 21 (average =18).
    - Respiratory problems: peak flow meter on average 316 ml per expiration (anything below 350 is symptoms of respiratory difficulties).
    - Anemia: 56% of women, and 51% of men are anemic.

TABLE 1—SELECTED HEALTH INDICATORS, BY POSITION IN THE PER CAPITA MONTHLY EXPENDITURE DISTRIBUTION

Indicator	Group		
	Bottom third	Middle third	Top third
Reported health status	5.87	5.98	6.03
No. symptoms self-reported in last 30 days	3.89	3.73	3.96
BMI	17.85	17.83	18.31
Hemoglobin below 12 g/dl	0.57	0.59	0.51
Peak flow meter reading	314.76	317.67	316.39
High blood pressure	0.17	0.15	0.20
Low blood pressure	0.06	0.08	0.09

- Refer to the following Table 9 and Table 10 from Deaton and Dreze (2009).
- The overall levels of child undernutrition in India (including “moderate” undernourishment) are still very high, both in absolute terms as well as relative to other countries.
  - Close to half of all Indian children are underweight, and about half suffer from anaemia.
- These are appalling figures, which place India among the most “undernourished” countries in the world.
  - Only two countries have higher proportions of underweight children (based on the same standards): Bangladesh and Nepal.
- While Pakistan and Sri Lanka have somewhat lower levels of child undernutrition, the whole south Asian region stands apart from the rest of the world in this respect.
  - Child undernutrition is much higher in south Asia (48.5% underweight in 1999) than in sub-Saharan Africa (29.6% underweight in 2005).

Table 9: Child Nutrition Indicators (1975-79 to 2004-05, rural)

	Proportion (%) of Undernourished Children[a]					Percentage Decline
	1975-79	1988-90	1996-97	2000-01	2004-05	(1975-79 to 2004-05)[b]
Weight-for-age						
Below 2 SD	77	69	62	60	55	29
Below 3 SD	37	27	23	21	18	51
Height-for-age						
Below 2 SD	79	65	58	49	52	34
Below 3 SD	53	37	29	26	25	53
Weight-for-height						
Below 2 SD	18	20	19	23	15	17
Below 3 SD	2.9	2.4	2.5	3.1	2.4	17
Prevalence of nutritional deficiency signs (%)						
Oedema	0.4	0.1	0.1	0	0	100
Marasmus	1.3	0.6	0.1	0.2	0	100
Bitot spots	1.8	0.7	0.7	0.8	0.6	67
Angular stomatitis	5.7	5.7	2.1	1.4	0.8	86

Table 10: Countries with the Highest Levels of Child Undernutrition (1996-2005)

Country	Proportion (%) of Children with Low "Weight for Age"
Nepal	48.3
Bangladesh	47.5
India	46.7
Timor-Leste	45.8
Yemen	45.6
Burundi	45.1
Madagascar	41.9
Sudan	40.7
Lao (People's Dem Rep)	40.4
Niger	40.1
Eritrea	39.6
Afghanistan	39.3

- Households do spend a considerable share of their budget on health care, and visit doctors frequently.
- The following Table 2 from Banerjee, Deaton and Duflo (EPW, 2004) shows the frequency of health care visits from their survey in Udaipur, Rajasthan.
  - Adults visit a health facility on average 0.51 times a month.
    - Poor: 0.43 times; Middle income: 0.54 times; Rich: 0.55 times.
  - Of these 0.51 visits, only 0.12 visits (less than a quarter) are to a public facility.
    - No one uses public facilities very much, and if anything, the poor use them less than the non-poor.
  - The majority of the rest of the visits (0.28 visits) are to private facilities.
  - The rest are to 'bhopas' (0.11 visits), who are traditional healers.
- In Udaipur, a pretty high share of household budget is devoted to health:
  - Poor: 7%; Middle income: 9%; Rich: 8%.
- The table titled "Health in the Household" shows the frequency of health care visits to private and public doctors by the very poor of the world.

Table 2: Frequency of Health Care Visits

	Per Capita Monthly Expenditure (Rs)	Total Number of Visits in the Last 30 Days			
		All	Public	Private	Bhopa
Panel A: Means					
All	470	0.51	0.12	0.28	0.11
Poor	219	0.43	0.09	0.22	0.12
Middle	361	0.54	0.11	0.29	0.13
Rich	770	0.55	0.15	0.33	0.07
Panel B:OLS Regressions: Dependent Variable: Number of Visits					
Middle		0.11	0.02	0.07	0.01
		(.052)	(.023)	(.034)	(.027)
Rich		0.12	0.06	0.11	-0.05
		(.05)	(.024)	(.034)	(.022)
Panel C: OLS Regressions, with Village Fixed Effects					
Middle		0.14	0.02	0.09	0.02
		(.047)	(.024)	(.033)	(.023)
Rich		0.13	0.04	0.11	-0.03
		(.05)	(.026)	(.036)	(.025)
Villages Fixed effects		yes	yes	yes	yes

Note: Omitted dummies in panel B and C: poor; Standard errors in parentheses below the coefficients.

Health in the Household

		In Last Month				
		Percent of HH Members Sick	A Household's Average # of Consultations	Percent of Households that met At Least Once with a Consultant		Infant Mortality
				Public	Private	
Rural						
	Cote d'Ivoire	21.4%	1.28	49.7%	3.2%	6.2%
	Guatemala					6.2%
	India - Hyderabad					
	India - Udaipur	46.1%	0.11	20.1%	58.1%	10.0%
	India - UP/Bihar	12.5%	0.81	13.9%	47.3%	7.7%
	Indonesia	24.2%	0.77	20.7%	27.3%	3.4%
	Mexico	46.3%	1.11	47.7%	0.0%	6.9%
	Nicaragua	34.9%	0.15	46.0%	5.0%	
	Pakistan	28.0%	0.45	24.0%	48.8%	16.7%
	Panama	15.2%	0.10	23.8%	0.0%	
	Papua New Guinea					
	Peru	11.1%	0.10	20.9%	8.5%	
	South Africa	12.5%	0.12	16.4%	6.9%	8.6%
	Tanzania	13.2%	0.07	23.2%	14.0%	8.7%
	Timor Leste	11.7%	0.21	30.2%	0.5%	

- While poor households do spend a considerable share of their budget on health care, and visit doctors frequently,
  - yet, take up of cheap, highly effective *preventive care* remains really low.
    - Less than 5% of children and 3% of pregnant mothers in Kenya sleep under a mosquito net (Cohen and Dupas, 2010).
    - 25% of mother breastfeed within an hour of birth in India, and the average extent of exclusive breast-feeding is only 2 months.
      - (WHO recommends breast-feeding within an hour of birth, and to exclusively breastfeed for 6 months)
    - NFHS reports only 44% of children in India are fully immunized, and this is probably an exaggeration.

2. Demand for Health: Price Effects

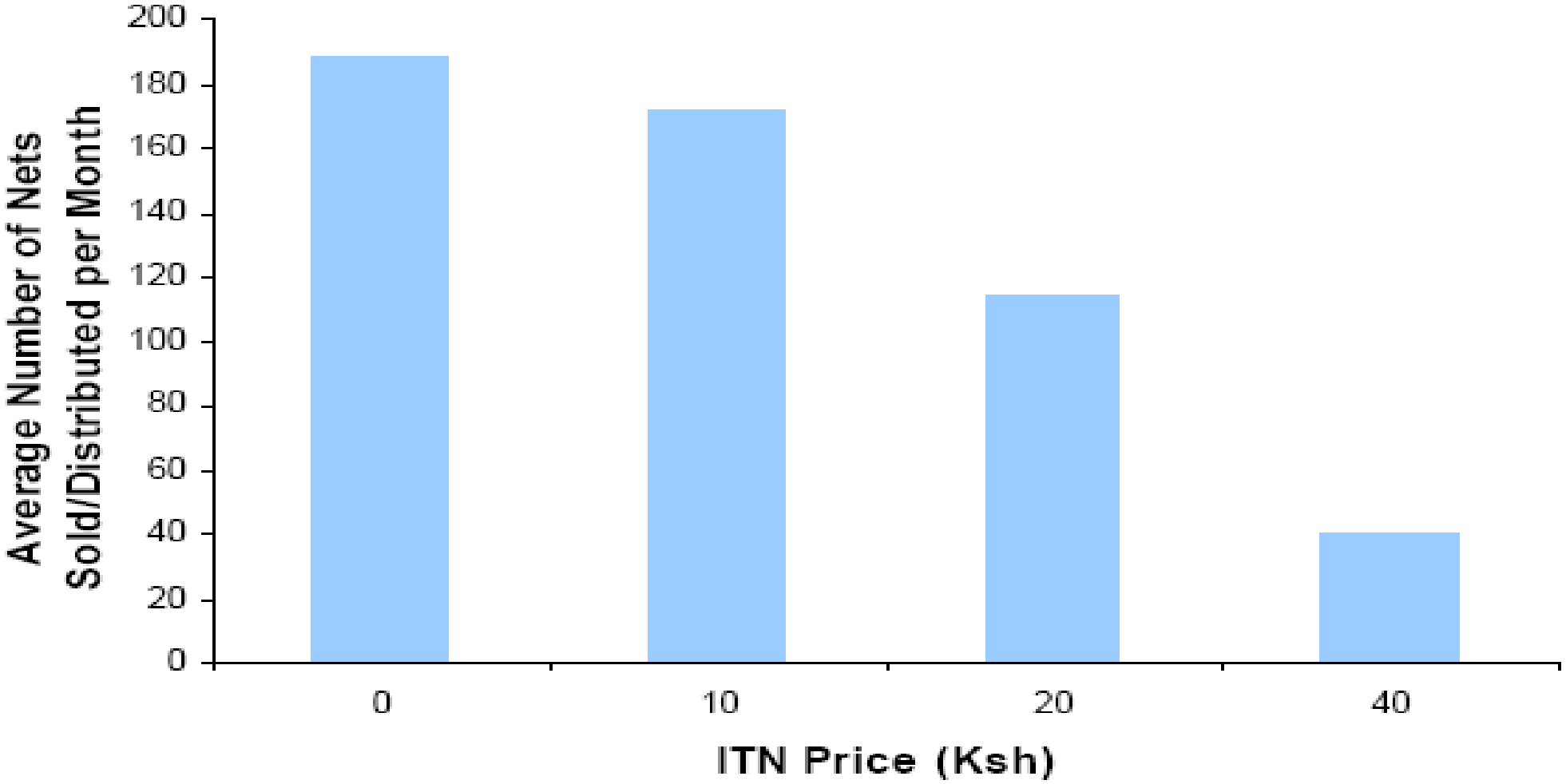
- Successful campaigns to eradicate malaria have been studied in a number of different countries.
  - Each of these studies compares high malaria-prevalence regions in the country with low-prevalence regions,
    - checks what happens to children born in these areas before and after the campaign.
- One study on malaria eradication in the US South and several countries in Latin America suggests:
  - a child who grew up malaria-free earns 50% more per year, for his entire adult life, compared to a child who got the disease.
- Qualitatively similar results were found in India, Paraguay and Sri Lanka.

- This result suggests that the financial return to investing in malaria prevention can be fantastically high.
  - A long-lasting insecticide-treated bed net costs at most $14 USD PPP in Kenya, and lasts about 5 years.
  - Assume conservatively that a child in Kenya sleeping under a treated net has 30% less risk of being infected with malaria compared to a child who doesn't.
  - In Kenya, an adult makes on average $590 USD PPP a year.
  - Thus, if malaria indeed reduces earnings in Kenya by 50%, and a treated bed net reduces risk by 30%,
    - then a $14 investment will result in the average return of $88 every year over the child's entire adult work life.

Cohen and Dupas (2010):

- They explored the price sensitivity of the take-up of insecticide treated bed nets by pregnant women in Kenya.
- In an experimental approach different randomly chosen maternity clinics were assigned to give away nets or to sell them at different prices.
- The purchase of nets was indeed very sensitive to the price.
  - Refer to the Figure in the next page.
  - Almost everybody took a free net home.
  - But the demand for nets fell to very close to zero at the price of about $0.75 USD PPP.
  - Uptake of nets dropped by 60% when the price increased from zero to $0.60 USD PPP.

Results: Demand
Monthly Net Sales by ITN Price



- Of the 9 million children who die before their fifth birthdays each year, the vast majority are poor children from South Asia and sub-Saharan Africa;
  - roughly one in five dies of *diarrhea*.
- Three “miracle drugs” could already save most of these children:
  - chlorine bleach, for purifying water;
  - salt and sugar, the key ingredients of the oral rehydration solution (ORS).
- A mere $100 spent on chlorine packaged for household use can prevent 32 cases of diarrhea.
- Dehydration is the main proxy cause of death from diarrhea, and ORS, which is close to being free, is a wonderfully effective way to prevent it.

- Yet, neither chlorine nor ORS is used very much.
  - In India, according to the UNICEF, only one-third of children who had diarrhea were given ORS.
  - In Zambia, chlorine is cheap and widely available.
    - At the cost of $0.18 USD PPP, a family of six can buy enough chlorine to purify its water supply, avoiding waterborne diarrhea.
    - But only 10% of families use it.
    - Although Zambia is a very poor country, $0.18 USD PPP for a bottle that lasts one month is really not a lot of money;
      - the average family spends $1.10 USD PPP per week just on cooking oil.

Ashraf, Berry and Shapiro (2010):

- An experimental intervention: a door-to-door sale of chlorine to about 1,000 households in Lusaka, Zambia.
  - Each household was offered a single bottle of chlorine for a randomly chosen offer price, which was above zero and at or below the prevailing price.
- Figure 2: At a price of 700 kwachas ($0.16 USD PPP) only about 50% buy it.
  - This fraction went up sharply when the price was lowered to 300 kwachas ($0.07 USD PPP).
    - But, remarkably, even at this reduced price almost one-fourth of the people did not buy the product.
- Column 1 of Table 2 shows that an increase of 100 Kw in the offer price results in a (highly statistically significant) reduction in purchases of about 7 percentage points.
- Columns 2 and 3 of Table 2 show that the results in column 1 are robust to adding baseline controls, and to restricting to households reached in the follow-up survey.

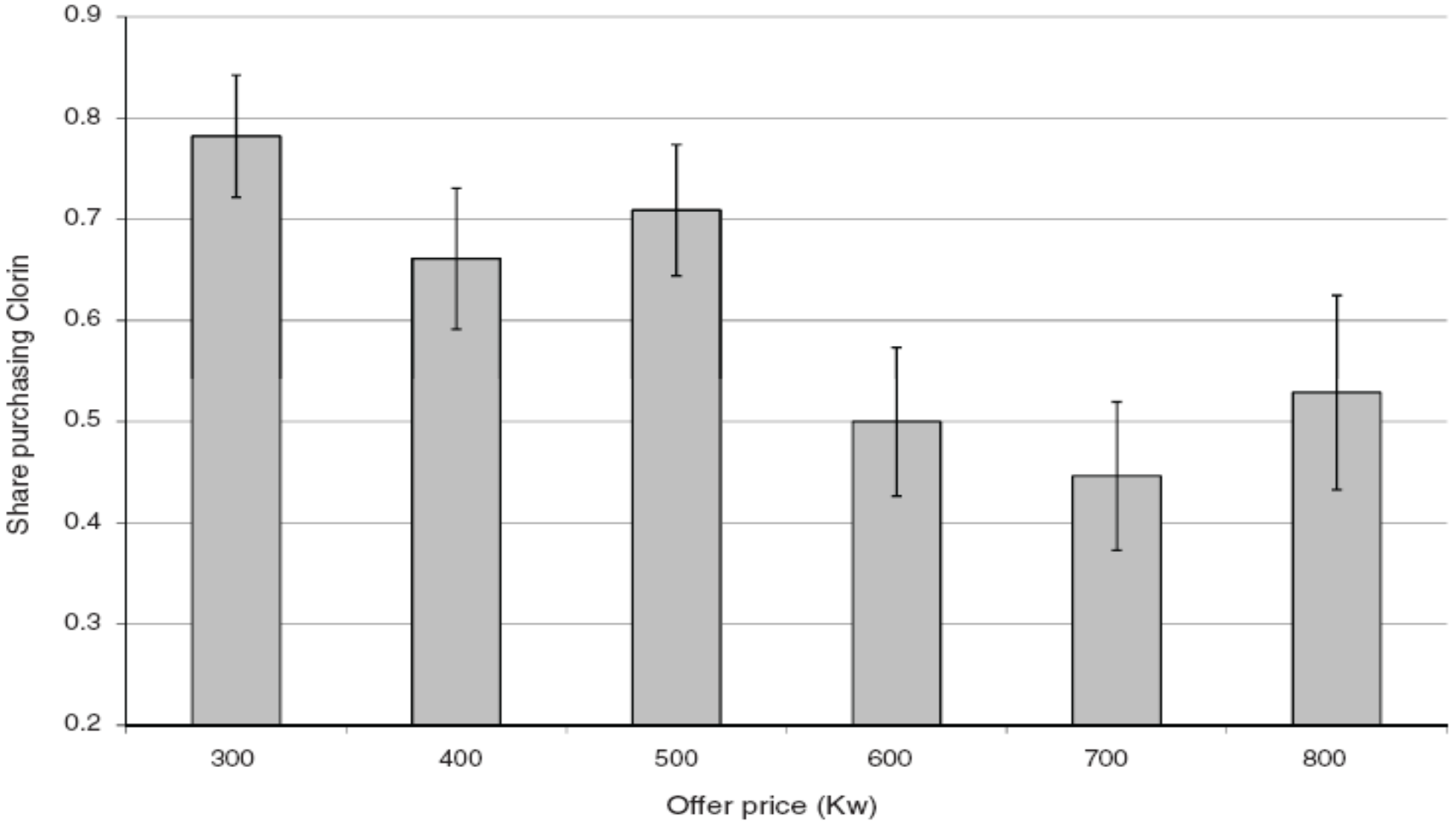


FIGURE 2. THE EFFECT OF OFFER PRICE ON PURCHASE OF CLORIN

Notes: Figure shows share of households purchasing Clorin in door-to-door marketing intervention, at different offer prices (in Zambian Kwacha). Error bars reflect $\pm$ 1.96 standard errors.

TABLE 2— ESTIMATES OF THE DEMAND FOR CLORIN
Dependent variable: Household purchased Clorin (dummy)

Sample	All (1)	All (2)	Follow-up (3)
Offer price	−0.0664	−0.0653	−0.0708
(100 Kw)	(0.0093)	(0.0094)	(0.0099)
Constant	0.9640	0.9578	0.9892
	(0.0516)	(0.0520)	(0.0547)
Baseline controls?	No	Yes	No
Sample mean of dependent variable	0.6116	0.6111	0.6135
Number of observations	1004	990	890

Notes: Standard errors in parentheses. Estimates are from linear probability models. "Baseline controls" includes baseline Clorin usage and water chlorination, general health behaviors and attitudes, household demographics, and locality fixed effects, as in Table A2, standardized to have a sample mean of 0. Fourteen households are missing data on one or more baseline controls due to questionnaire refusals. Column (3) restricts the sample to respondents reached for the follow-up survey.

Banerjee, Duflo, Glennerster and Kothari (2010):

- Immunization is a highly cost effective way of improving survival in children in developing countries.
- However, every year throughout the world an estimated 27 million children and 40 million pregnant women do not receive the basic package of immunizations (as defined by WHO and UNICEF).
- According to the NFHS-3, in India only 44% of children aged 1-2 years have received the basic package.
  - That drops to 22% in rural Rajasthan, the setting of the present study, and was less than 2% in the study area, rural Udaipur.

- The Experiment: Clustered randomized controlled study of 1640 children aged 1-3.
  - 134 villages were randomized to one of three groups:
    - Control or no intervention; 860 children in 74 villages;
    - Intervention A: A once monthly reliable immunization camp; 379 children from 30 villages;
    - Intervention B: A once monthly reliable immunization camp with small incentives; 382 children from 30 villages;
      - offer 2 pounds of *dal* (raw lentils) for each immunization, and a set of stainless still plates for completed immunization.

- The Results:
  - Refer to Figure 2.
  - Among children aged 1-3 rates of full immunization were
    - 39% for intervention B villages (reliable immunization with incentives),
    - 18% for intervention A villages (reliable immunization without incentives),
    - 6% for control villages.
  - Children in areas neighbouring intervention B villages were also more likely to be fully immunized than those from areas neighbouring intervention A villages.
  - Figure 3 shows that the difference between intervention B and intervention A was more marked for full immunization than for the number of immunizations received, and
    - disappeared for the probability of receiving at least one injection.

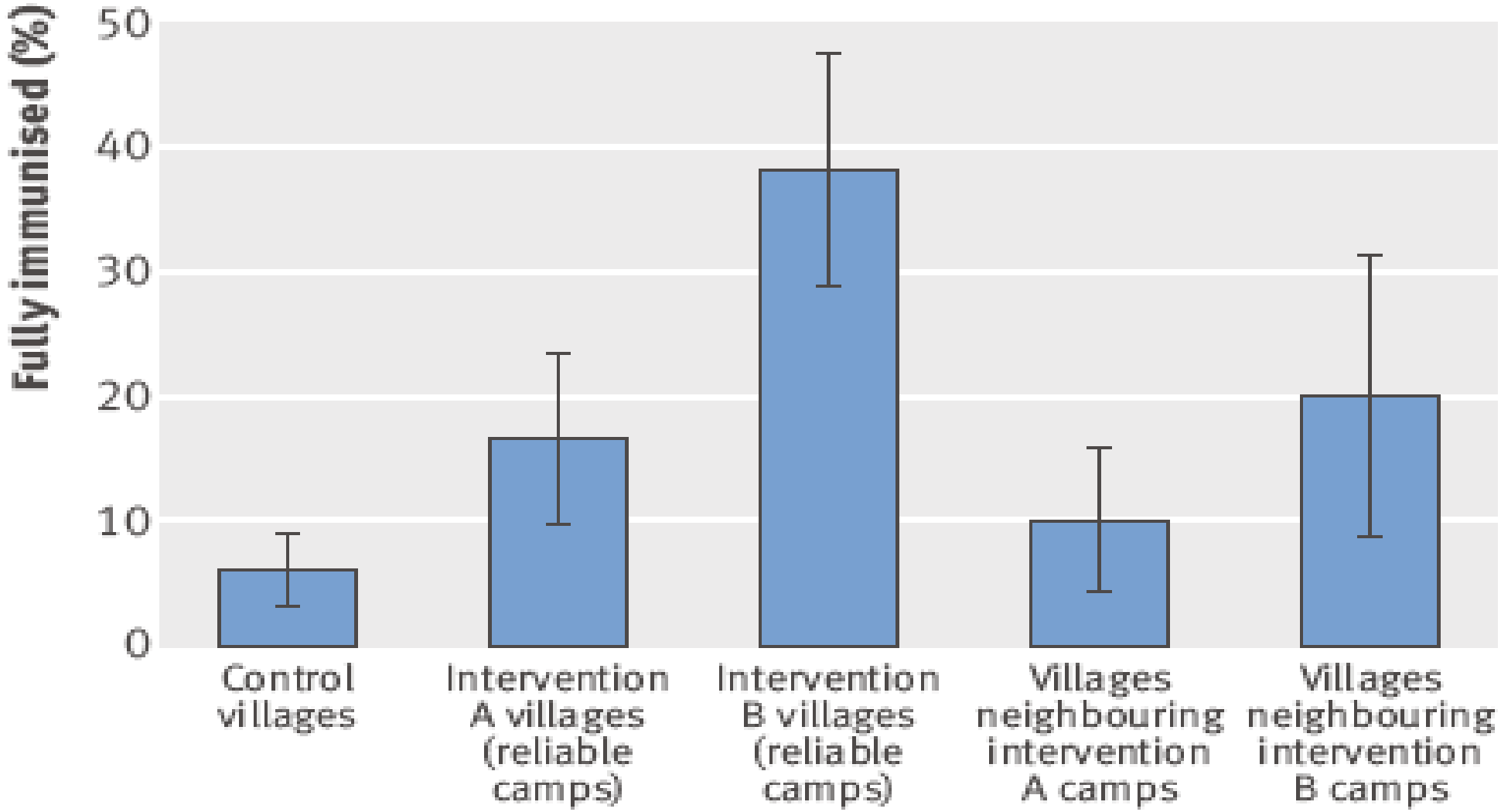


Fig 2 | Percentage of children aged 1-3 years fully immunised by treatment status

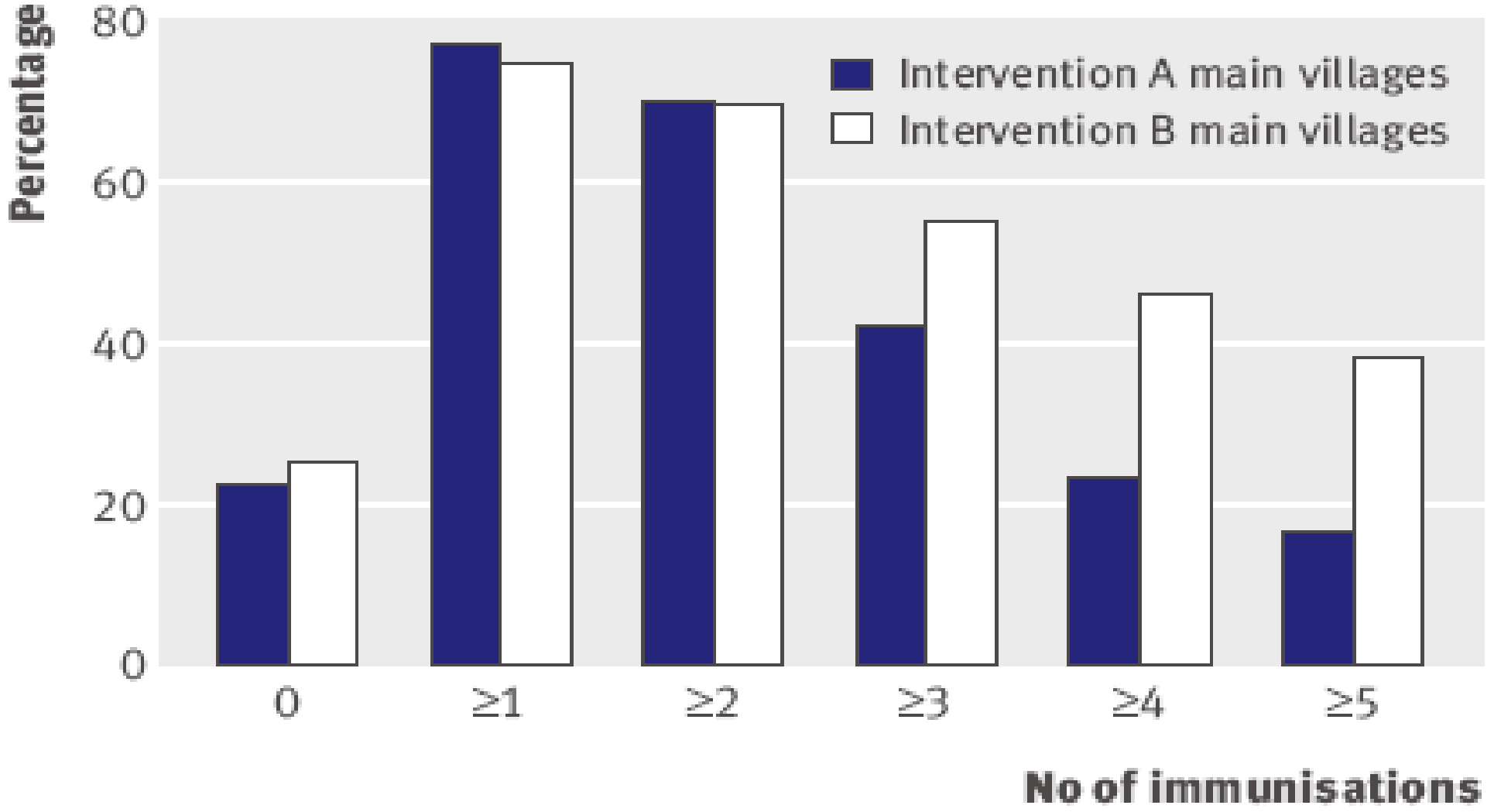


Fig 3 | Number of immunisations received by children aged 1-3 years

Health Seeking Behaviour: Summary

- Although achieving a minimum nutrition standard is fairly cheap, yet there is plenty of malnutrition, even outside countries that face particularly acute food crises.
- While poor households do spend a considerable share of their budget on health care and visit doctors frequently, yet take up of cheap, highly effective *preventive care* remains really low.
- Price-elasticity of demand for preventive health care services is very high, both for positive as well as negative prices.
  - Positive prices (even small) discourage use;
  - Small rewards greatly encourage use.

3. Productivity Effects of Health

- There are strong biological reasons to think that health (and nutrition) affects productivity: strength, days of illness, and so on.
- At the micro-level, some indicators of health show fairly strong relationship with earnings.
  - Recall the relationship between calorie consumption and productivity in Strauss (1986).
- At the macro-level, some studies have argued extremely high impact of health on GDP per capita.
  - Gallup and Sachs (2001) argue that wiping out malaria in sub-Saharan Africa could increase that continent's per capita growth rate by as much as 2.6% a year.
- There are potential problems with both micro and macro estimates.

- Does malaria hold back economic progress?
  - Simple correlations between malaria and productivity cannot answer this question.
  - Malaria might depress productivity, but the failure to eradicate malaria might equally be a symptom of underdevelopment, itself caused by poor institutions.
- Although cross-country regression studies show a strong correlation between measures of health (e.g., life expectancy) and economic growth, they have not established a causal effect of health and disease on economic growth.
  - Since countries suffering from short life expectancy and ill health are also disadvantaged in other ways (and often this is the reason for their poor health outcomes),
    - such macro studies may be capturing the negative effects of these other, often omitted, disadvantages.

- We will focus on both micro and macro estimates of the productivity impact of health which are trying to go around these problems.

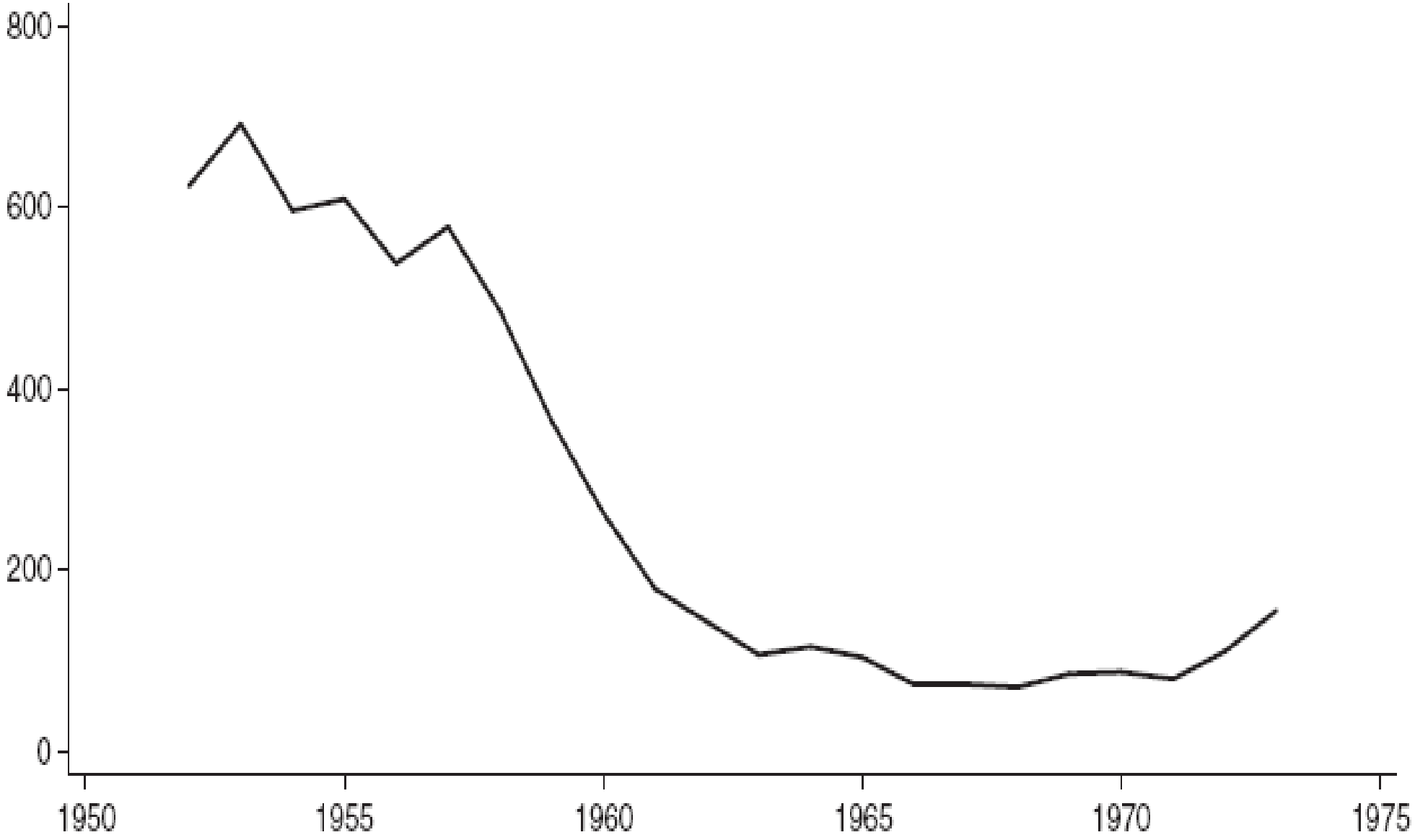
3.1 Bleakley (2010)

- Recall the concern of circular causality raised with the question “Does malaria hold back economic progress?”
- How can we disentangle this circular causality?
- The standard econometric answer is to consider plausibly exogenous variation in malaria.
  - A possible source of such variation comes from targeted interventions in public health.
- Bleakley (2010) uses the malaria-eradication campaigns in the US (circa 1920) and in Brazil, Colombia, and Mexico (circa 1955) to measure how much childhood exposure to malaria depresses labour productivity.

Research Design

1. The commencement of eradication was due substantially to factors external to the affected regions.
   - The eradication campaigns relied heavily upon critical innovations to knowledge from outside the affected areas.
   - Such innovations were not related to or somehow in anticipation of the future growth prospects of the affected areas;
   - This should mitigate the concern about policy endogeneity and reverse causality.
2. The anti-malaria campaigns achieved considerable progress against the disease in less than a decade.
   - Following figure (Panel A, Figure 1) shows malaria cases per capita in Colombia.
   - This is a sudden change on historical time scales, especially when compared with trend changes in mortality throughout recent history.
     - This allows identifying likely childhood exposure with sufficient precision.

Panel A. Large decline in malaria following onset of spraying campaign



3. An additional element in the identification strategy is that these four countries are geographically variegated;
   - within each country, some regions have climate that support malaria transmissions, while other regions do not.
   - Areas with high malaria infection rates had more to gain from eradication, but the non-malarious areas serve as a comparison group,
     - filtering out, for example, common trends in national policy.

- Research design of Bleakley (2010) combines the relatively rapid impact of the treatment campaigns with cross-area heterogeneity.
  - The variable of interest is the pre-eradication malaria intensity.
  - By comparing the cross-cohort evolution of outcomes (e.g., adult income) across areas with distinct infection rates,
    - one can assess the contribution of the eradication campaigns to the observed changes.

4. The timing of the eradication campaign should induce variation in childhood malaria infection that has a marked pattern across year-of-birth cohorts.
   - Consider Figure 2.
   - Consider a campaign that starts in year zero and takes effect instantaneously.
     - Cohorts born after this date will be exposed to the campaign for their entire childhood.
     - Cohorts who were already adults in year zero will have no childhood exposure to the campaign.
     - The “in-between” cohorts will be partially exposed during childhood.
   - The study exploits this timing in two ways.
     - Pre/Post Comparisons: Compare the “born after” cohorts to the “already adult” cohorts by taking differences across these cohort groups.
     - Graphical Evidence: Use the functional form of childhood exposure in estimation using data for all cohorts.

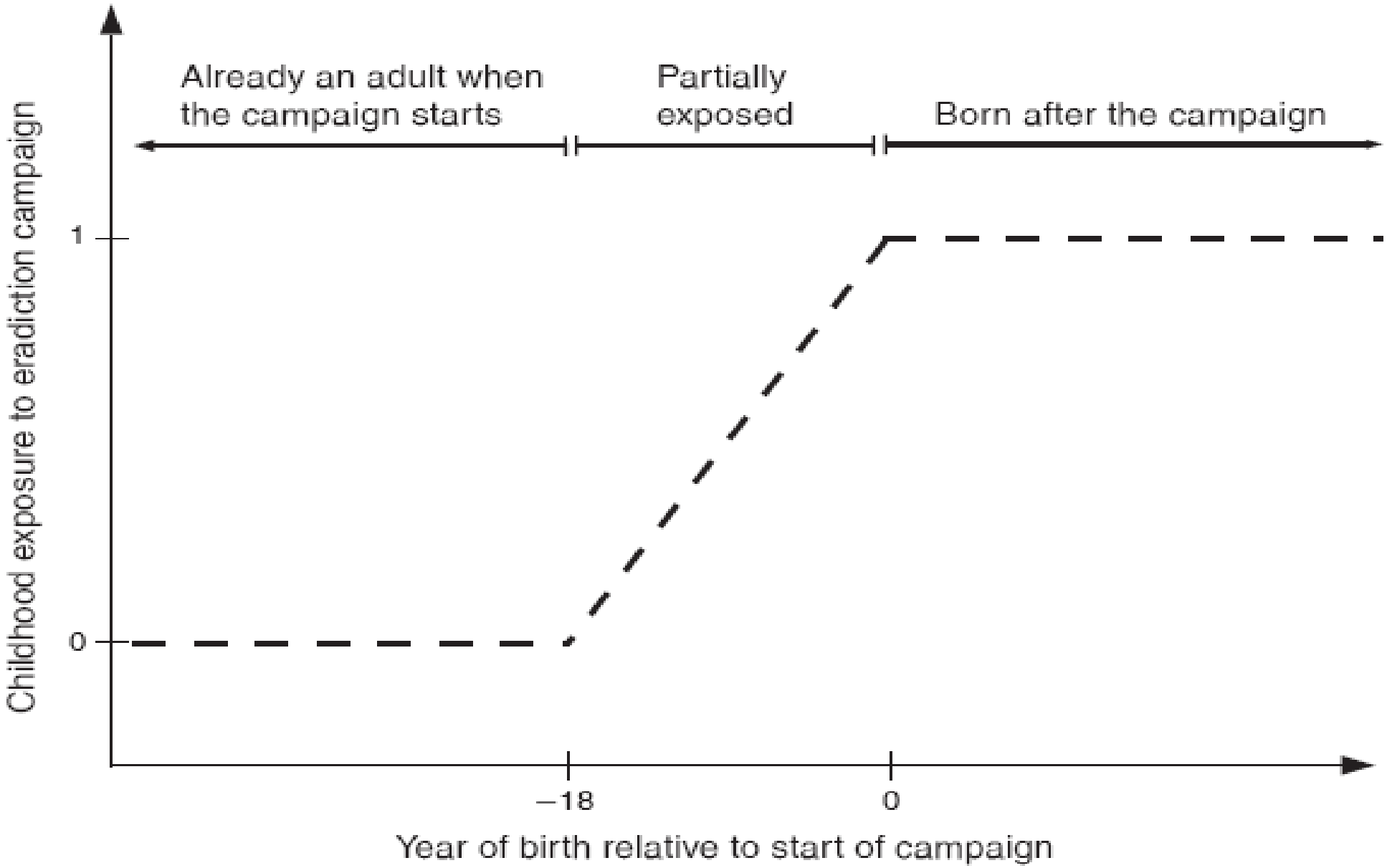


FIGURE 2. CHILDHOOD EXPOSURE TO ERADICATION CAMPAIGN

Pre/Post Comparisons

- For each place of birth, the outcome variables are cross-cohort differences (i.e., 'born after' minus 'born well before') in the socioeconomic measures.
- The basic equation to be estimated is

$$Y_{j,post} - Y_{j,pre} = \beta M_{j,pre} + X_{j,pre}\Gamma + \alpha + \varepsilon_{j,post}. \quad (1)$$

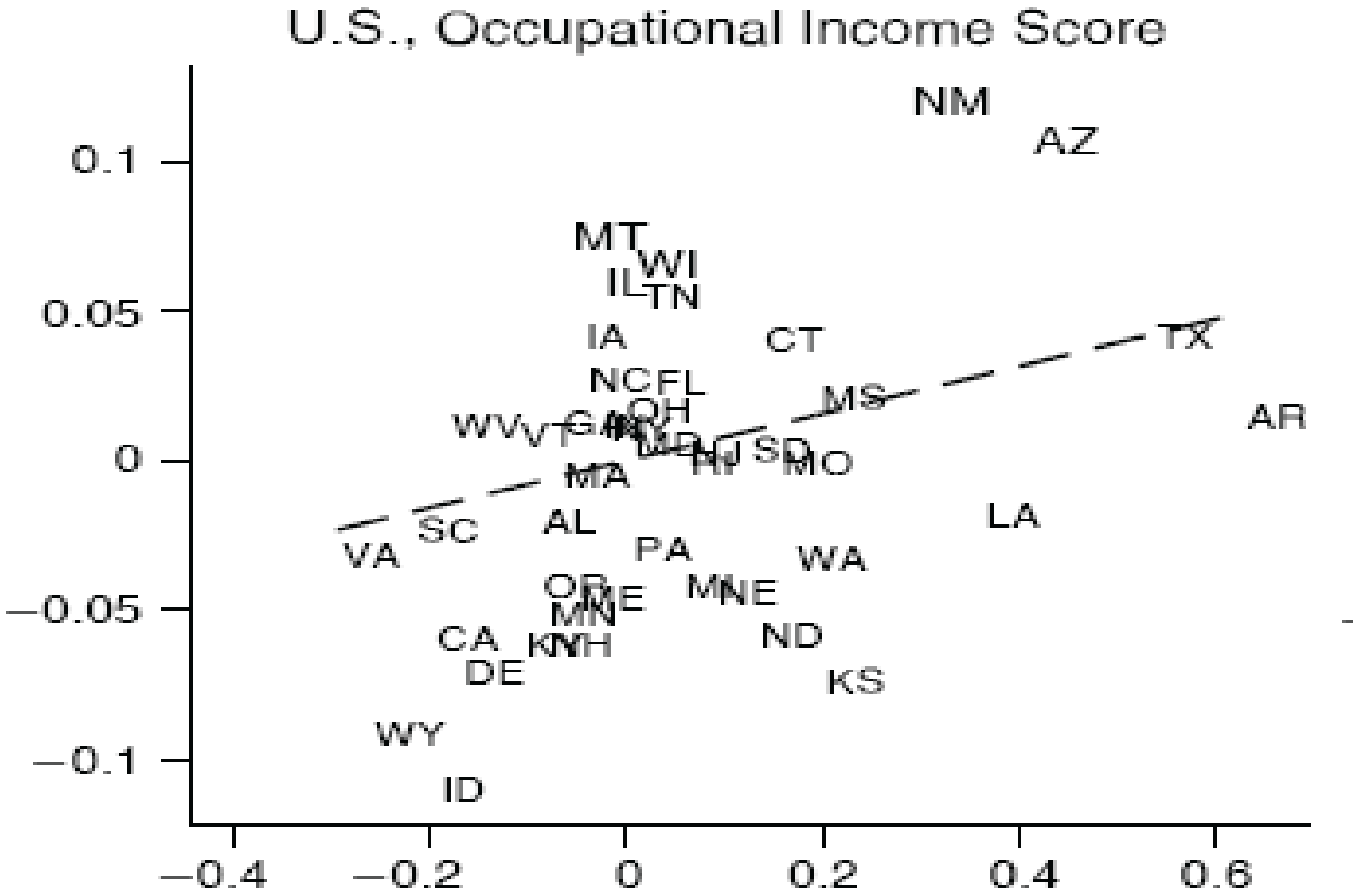
  - Y is some socioeconomic outcome for state or municipio j.
  - 'post' refers to a year of birth following the malaria-eradication campaign, while 'pre' indicates being born (and having become an adult) prior to the advent of the campaign.
  - $M_{j,pre}$ is the pre-program malaria incidence.
  - The X variables are a series of controls, and α a constant term.
  - The parameter of interest is β.

Pre/Post Comparisons: United States

- Table 1 reports the results for the United States.
  - The first row of Panel A contains estimates for the basic specification of equation (1).
    - The estimates for malaria are not substantially affected by the inclusion of a number of additional control variables.
  - The following figure displays a scatter plot of cross-cohort income growth versus malaria.
- These estimates are substantial, but not unreasonable, magnitudes for the effect of childhood exposure to malaria.
  - In the states with high levels of malaria, cohorts born after the anti-malaria campaign earned 10-20% more than the previous generation,
    - relative to the benchmark of cohorts in malaria-free states.

TABLE 1—CROSS-COHORT DIFFERENCES AND MALARIA: UNITED STATES

	Malaria mortality (fraction of total), 1890		Malaria ecology (Hong)	
Dependent variable:				
Occupational Income Score	X		X	
Duncan's Socioeconomic Index		X		X
Panel A. Alternative control sets				
Additional controls:				
Basic specification only	0.112***	0.134**	0.236***	0.219***
	(0.039)	(0.065)	(0.032)	(0.053)
Health	0.100***	0.144**	0.225***	0.280***
	(0.038)	(0.067)	(0.031)	(0.048)
Education	0.136***	0.131**	0.219***	0.206***
	(0.041)	(0.062)	(0.027)	(0.055)
Other	0.094**	0.115*	0.204***	0.178***
	(0.044)	(0.063)	(0.029)	(0.068)
Full controls	0.110**	0.172*	0.215***	0.265***
	(0.049)	(0.094)	(0.049)	(0.096)


U.S., Occupational Income Score
NM
AZ
MT
WI
IL
TN
IA
CT
TX
NC
FL
MS
OH
AR
WV
MO
MA
LA
SC
AL
VA
PA
WA
OR
ME
MN
NE
CA
ND
DE
KS
WY
ID
0.1
0.05
0
−0.05
−0.1
−0.4
−0.2
0
0.2
0.4
0.6

Pre/Post Comparisons: Brazil, Colombia and Mexico

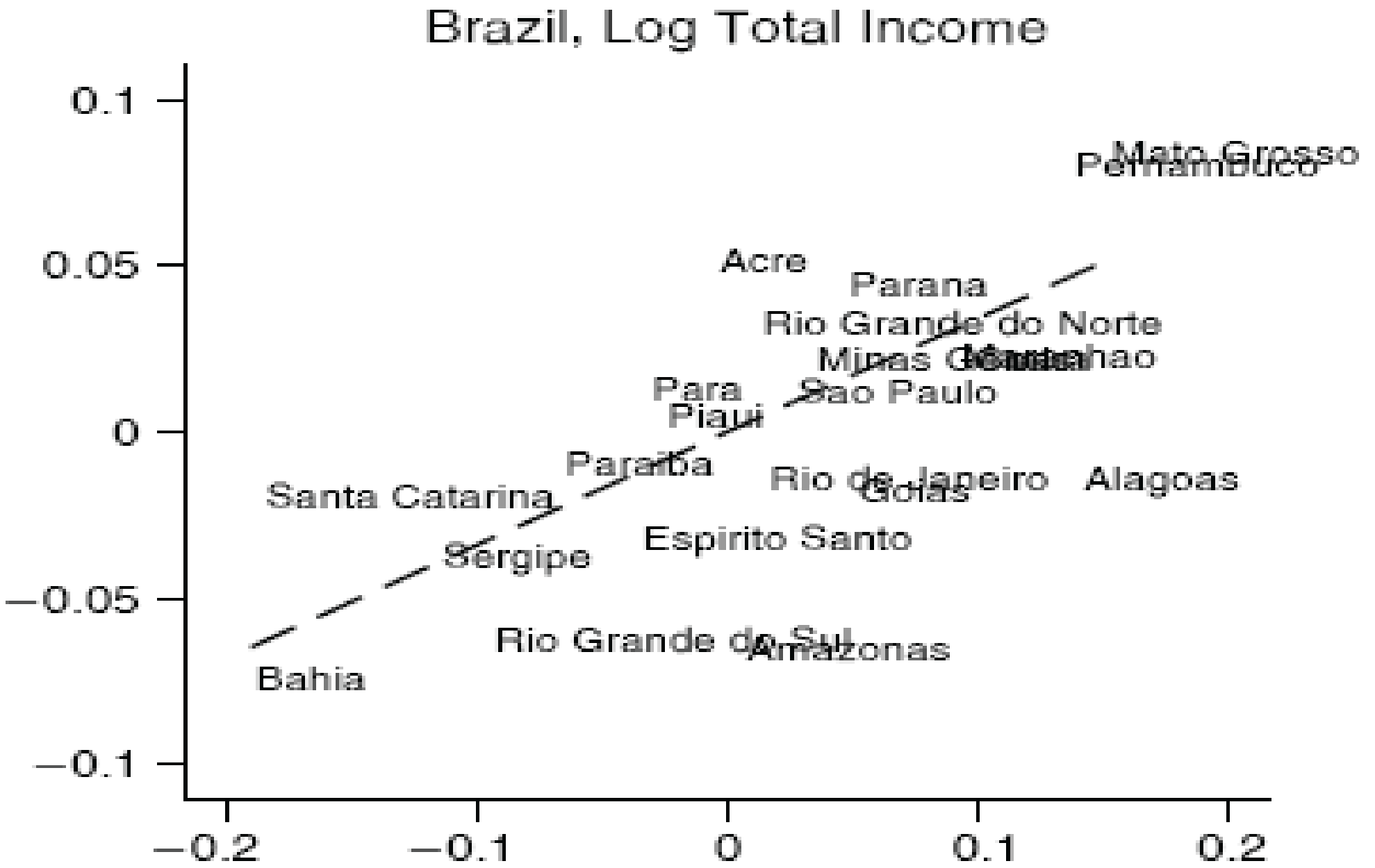
- In Brazil and Mexico, malarious areas saw faster cross-cohort growth in income and literacy, but there is mixed evidence regarding differences in years of schooling.
  - Table 2 reports the cross-cohort differences for Brazil and Mexico.
- Results from Colombia suggest that cross-cohort growth in income, literacy, and education was higher in the areas with more perverse malaria ecology.
  - Table 3 reports the estimates for Colombia.
- The following figures display the scatter plots of cross-cohort income growth versus malaria.

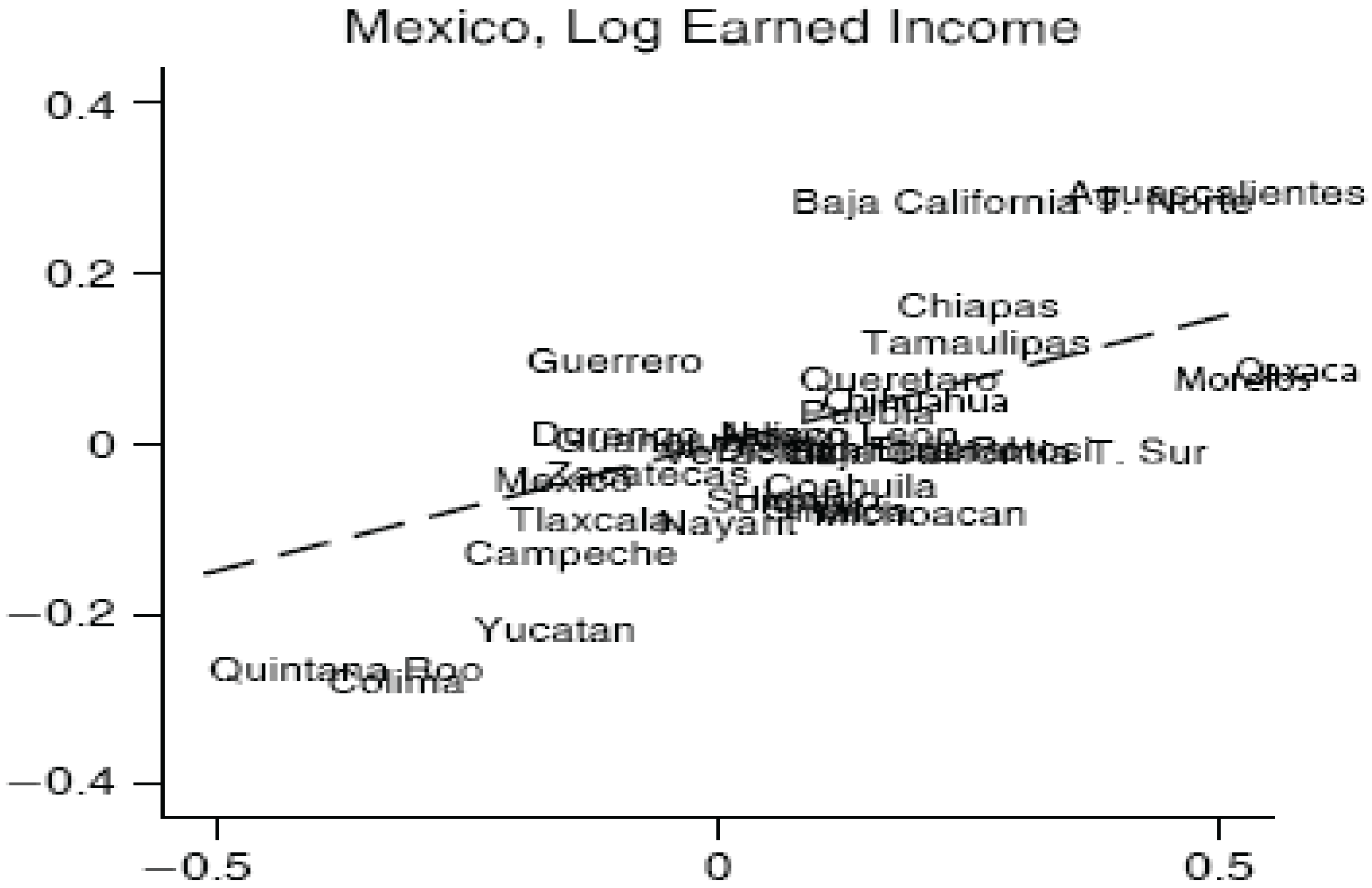
TABLE 2—CROSS-COHORT DIFFERENCES AND MALARIA: BRAZIL AND MEXICO

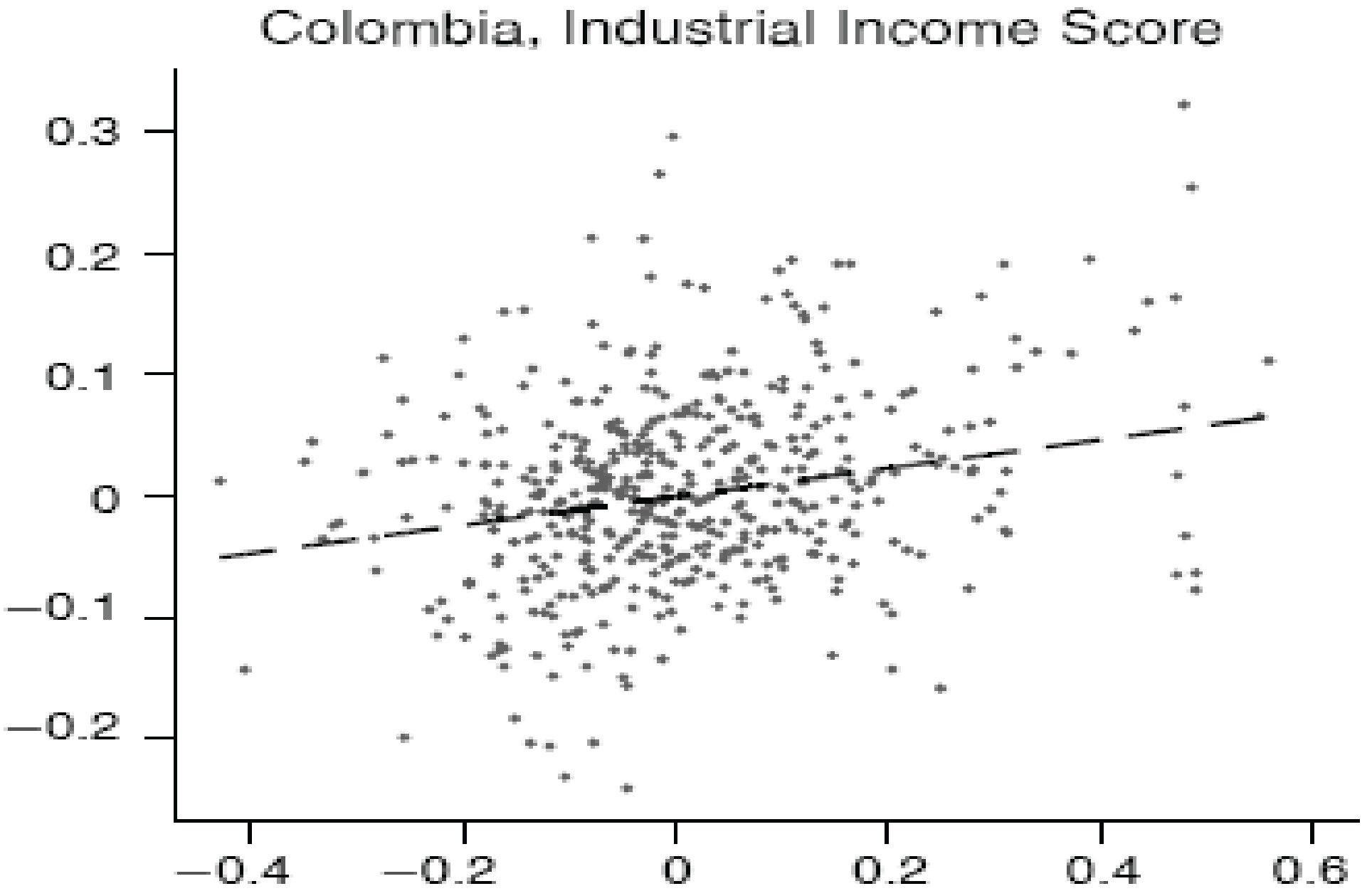
	Brazilian states ($N = 24$)				Mexican states ($N = 32$)		
Dependent variables: Differences across cohorts in…	Literacy	Education	Log total income	Log earned income	Literacy	Education	Log earned income
Panel A. Estimates using ordinary least squares							
Specification:							
Basic	0.063	0.555	0.351**	0.267**	0.116***	0.058	0.292***
	(0.063)	(0.607)	(0.173)	(0.131)	(0.032)	(0.298)	(0.112)
Include infant mortality	0.063	0.576	0.366**	0.262*	0.119***	0.138	0.286**
	(0.063)	(0.581)	(0.147)	(0.136)	(0.032)	(0.237)	(0.112)
Include sectorial shares	0.131***	1.288**	0.434**	0.283***	0.032	−0.234	0.196
	(0.042)	(0.597)	(0.183)	(0.094)	(0.039)	(0.247)	(0.135)
Full controls	0.147***	0.995**	0.393**	0.283*	0.035	−0.247	0.254*
	(0.042)	(0.487)	(0.178)	(0.147)	(0.035)	(0.260)	(0.148)

TABLE 3—CROSS-COHORT DIFFERENCES AND MALARIA: COLOMBIA

	Malaria ecology (Poveda)			Malaria ecology (Mellinger)		
Dependent variables: Differences across cohorts in…	Literacy	Years of schooling	Income index	Literacy	Years of schooling	Income index
Panel A. Alternative controls						
Additional controls:						
None (basic specification)	0.035***	0.168*	0.065***	0.071***	0.064	0.048***
	(0.013)	(0.088)	(0.011)	(0.016)	(0.108)	(0.014)
Conflict	0.032***	0.175*	0.063***	0.068***	0.068	0.046***
	(0.012)	(0.090)	(0.011)	(0.016)	(0.110)	(0.014)
Economic activity	0.008	0.194**	0.057***	0.043***	0.156	0.039***
	(0.010)	(0.089)	(0.012)	(0.013)	(0.110)	(0.014)
Other diseases	0.024*	0.180**	0.065***	0.058***	0.057	0.042***
	(0.013)	(0.089)	(0.012)	(0.016)	(0.114)	(0.015)
Full controls	0.006	0.165*	0.064***	0.046***	0.076	0.034**
	(0.011)	(0.095)	(0.013)	(0.015)	(0.117)	(0.015)


Brazil, Log Total Income
0.1
0.05
0
−0.05
−0.1
−0.2
−0.1
0
0.1
0.2
Mato Grosso
Pernambuco
Acre
Parana
Rio Grande do Norte
Para
Sao Paulo
Piaui
Paraiba
Rio de Janeiro
Alagoas
Goias
Santa Catarina
Espirito Santo
Sergipe
Rio Grande do Sul
Amazonas
Bahia


Mexico, Log Earned Income
0.4
0.2
0
−0.2
−0.4
−0.5
0
0.5
Baja California
Chiapas
Tamaulipas
Guerrero
Queretaro
Morelos
Oaxaca
T. Sur
Tlaxcala
Campeche
Yucatan
Quintana Roo
Colima


Colombia, Industrial Income Score
0.3
0.2
0.1
0
−0.1
−0.2
−0.4
−0.2
0
0.2
0.4
0.6

- Childhood exposure to the malaria-eradication campaign is associated with a log income gain of around 0.3 and 0.2 in Brazil and Mexico, respectively.
- The estimate for Colombia (approximately 0.04) is considerably lower.
  - But this is most likely because of the crudeness of the income score.
  - An adjusted number for Colombia on this basis (≈ 0.22) would be quite comparable to Brazil or Mexico.
- These reduced-form magnitudes point to a larger impact in Latin America than in the US south.
  - This is consistent with pre-eradication malaria infection rates being lower in the southern United States than in Latin America.

Normalizing by the Probability of Childhood Infection

- Expanding upon the reduced-form estimates above, Bleakley (2010) renormalizes the effects on adult income per probability of malaria infection.
- Table 5 shows that the effect of childhood malaria infection on adult wages is substantial.
  - Being infected with malaria through childhood leads to a reduction in adult income of approximately 50%.
  - These estimates are shown in the last row of Table 5.

TABLE 5—APPROXIMATE EFFECTS ON ADULT INCOME PER PROBABILITY OF CHILDHOOD MALARIA INFECTION

	United States		Brazil		Colombia	Mexico
Dependent variables:	Occupational income score	Duncan's index	Log total income	Log earned income	Industrial income score	Log earned income
Estimates:						
Reduced-form differences; 95/5 percentile comparison	0.14	0.18	0.37	0.27	0.28 (adjusted)	0.26
Maximal endemicity (approximate malaria infection rate)	Mesoendemic (0.3)		Hyperendemic (0.625)		Hyperendemic (0.625)	Hyperendemic (0.625)
Income effect per probability of childhood infection	0.47	0.60	0.59	0.45	0.45	0.41

Summary

- Bleakley (2010) establishes that being exposed to malaria in childhood depresses labor productivity as an adult.
- In the most malarious areas of the Latin American countries studied, cohorts born after the anti-malaria campaign earned approximately 25 percent more than the previous generation, relative to the cross-cohort change in the malaria-free areas.
  - The comparable change in the United States was approximately 12 percent.
- Considered in terms of the probability of persistent childhood infection, this effect is substantial.
  - Estimates indicate that reducing one's point-in-time probability of childhood malaria infection from 1 to 0 results in earning approximately 50 percent more as an adult.

3.2 Acemoglu and Johnson (2007)

- Recall the limitation of cross-country regression studies showing a strong correlation between measures of health and economic growth.
  - Since countries suffering from short life expectancy and ill health are also disadvantaged in other ways (and often this is the reason for their poor health outcomes),
    - such macro studies may be capturing the negative effects of these other, often omitted, disadvantages.
- Acemoglu and Johnson (2007) investigates the effect of general health conditions, proxied by life expectancy at birth, on economic growth.
  - They use the same identification strategy as Bleakley (2010), but in a cross-country setting, for the diseases against which significant progress were made in the post-war period (mainly tuberculosis, pneumonia, malaria).

- While a range of micro studies demonstrate the importance of health for individual productivity,
  - they do not resolve the question of whether health differences are at the root of the large world-wide income differences because they do not incorporate general equilibrium effects.
- The most important general equilibrium effect arises because of diminishing returns to effective units of labor, for example, because land and/or physical capital are supplied inelastically.
  - In the presence of such diminishing returns, micro estimates may exaggerate the aggregate productivity benefits from improved health,
    - particularly when health improvements are accompanied by population increases.

The Instrument for Life Expectancy: Predicted Mortality from the International Epidemiological Transition

- International epidemiological transition refers to the large improvements in life expectancy driven by international health interventions starting in the 1940s:
  - more effective public health measures (WHO, UNICEF);
  - the introduction of new chemicals and drugs,
    - for example, discovery and mass production of penicillin and streptomycin, or the discovery and widespread use of DDT against mosquito vectors.
- This episode led to an unprecedented improvement in life expectancy in a large number of countries.
  - Figure 1 shows this by plotting life expectancy in countries that were initially (circa 1940) poor, middle-income, and rich.
    - While in the 1930s life expectancy was low in many poor and middle-income countries, this transition brought their levels of life expectancy close to those prevailing in richer parts of the world.

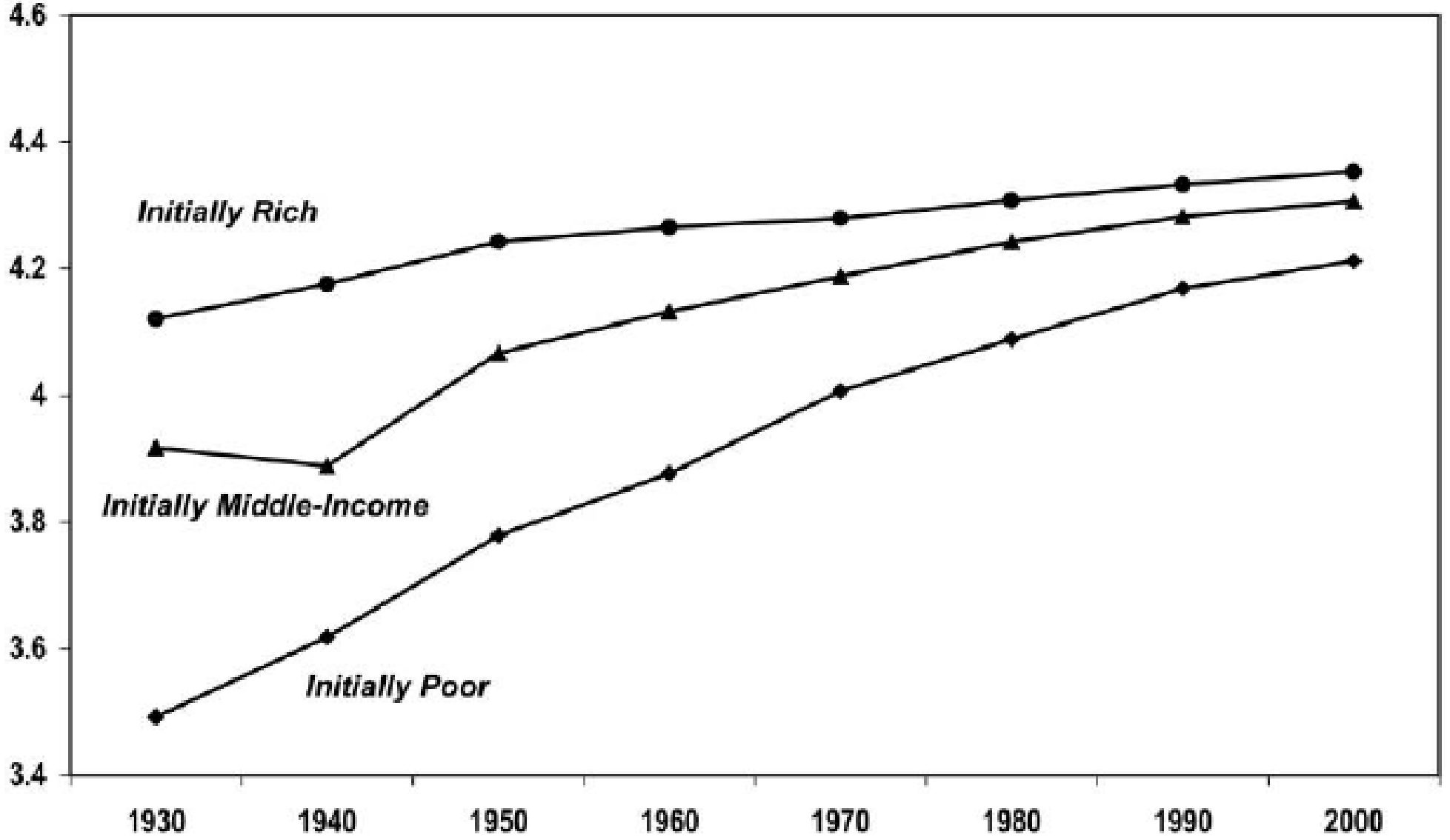


FIG. 1.—Log life expectancy at birth for initially rich, middle-income, and poor countries in the base sample.

- The international epidemiological transition provides us with an empirical strategy to isolate potentially exogenous changes in health conditions.
  - Instrument for life expectancy: *Predicted Mortality*:

    The early data on mortality by disease allow us to create an instrument for changes in life expectancy based on

    - the pre-intervention distribution of mortality from various diseases around the world, and the dates of global intervention.

- The only source of variation in this instrument comes from the interaction of baseline cross-country disease prevalence with global intervention dates for specific diseases.
  - Acemoglu and Johnson (2007) document that the predicted mortality instrument has a large and robust effect on changes in life expectancy starting in 1940 (**Figure 3**),
  - but has no effect on changes in life expectancy prior to this date, i.e., before the key interventions (**Figures 5 and 6**).

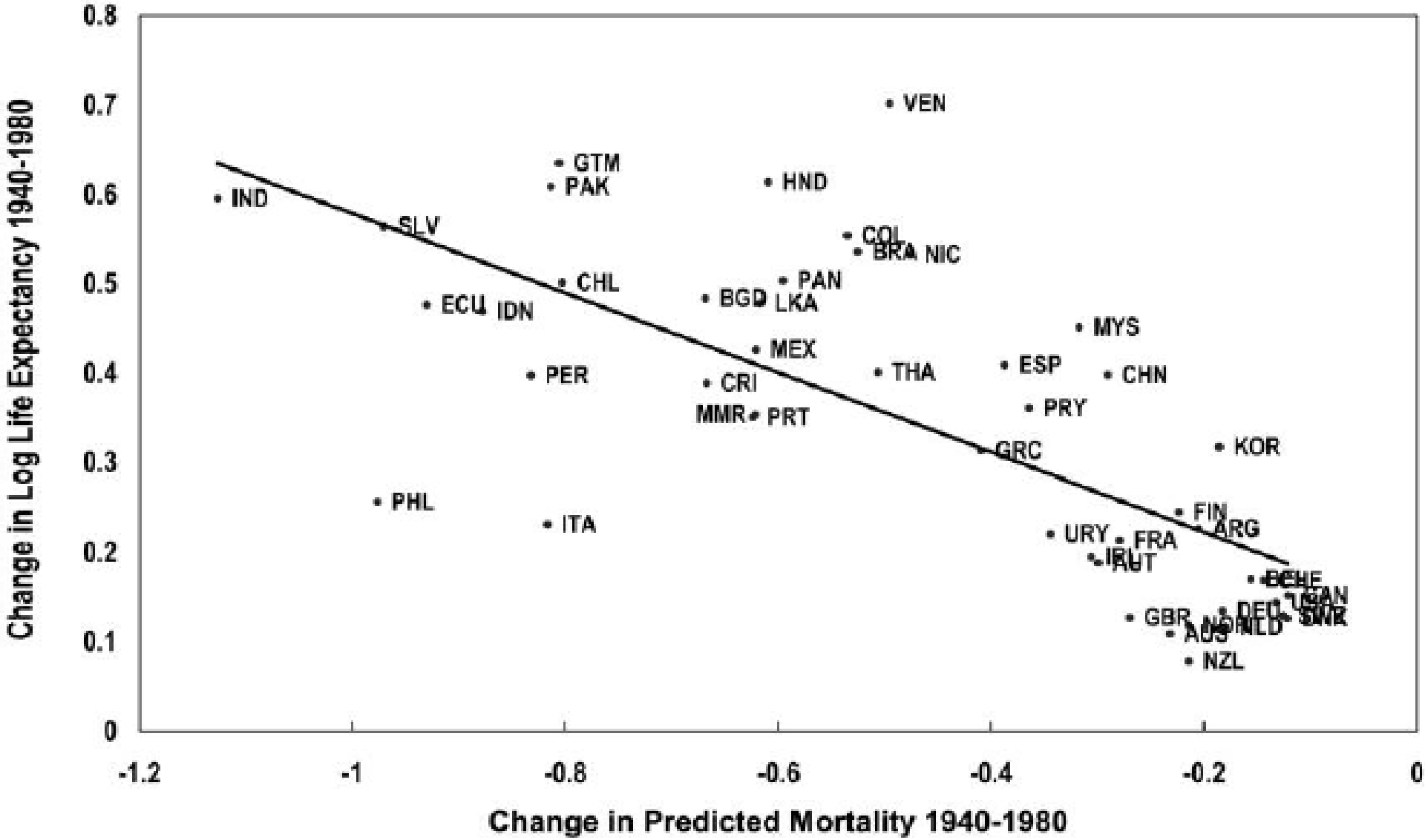


FIG. 3.—Change in log life expectancy and change in predicted mortality, 1940–80, base sample.

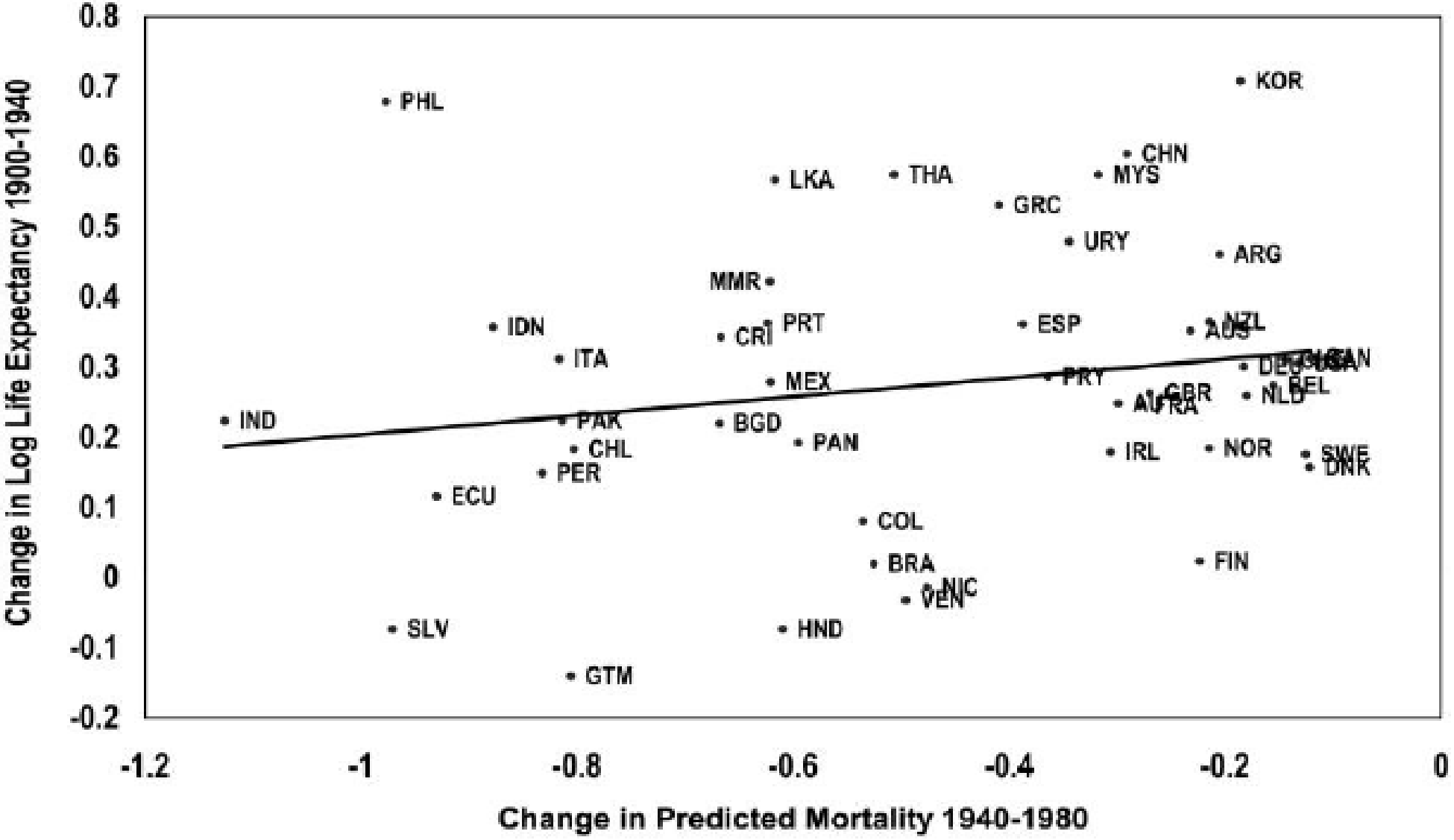


FIG. 5.—Change in log life expectancy 1900–1940 and change in predicted mortality, 1940–80, base sample.

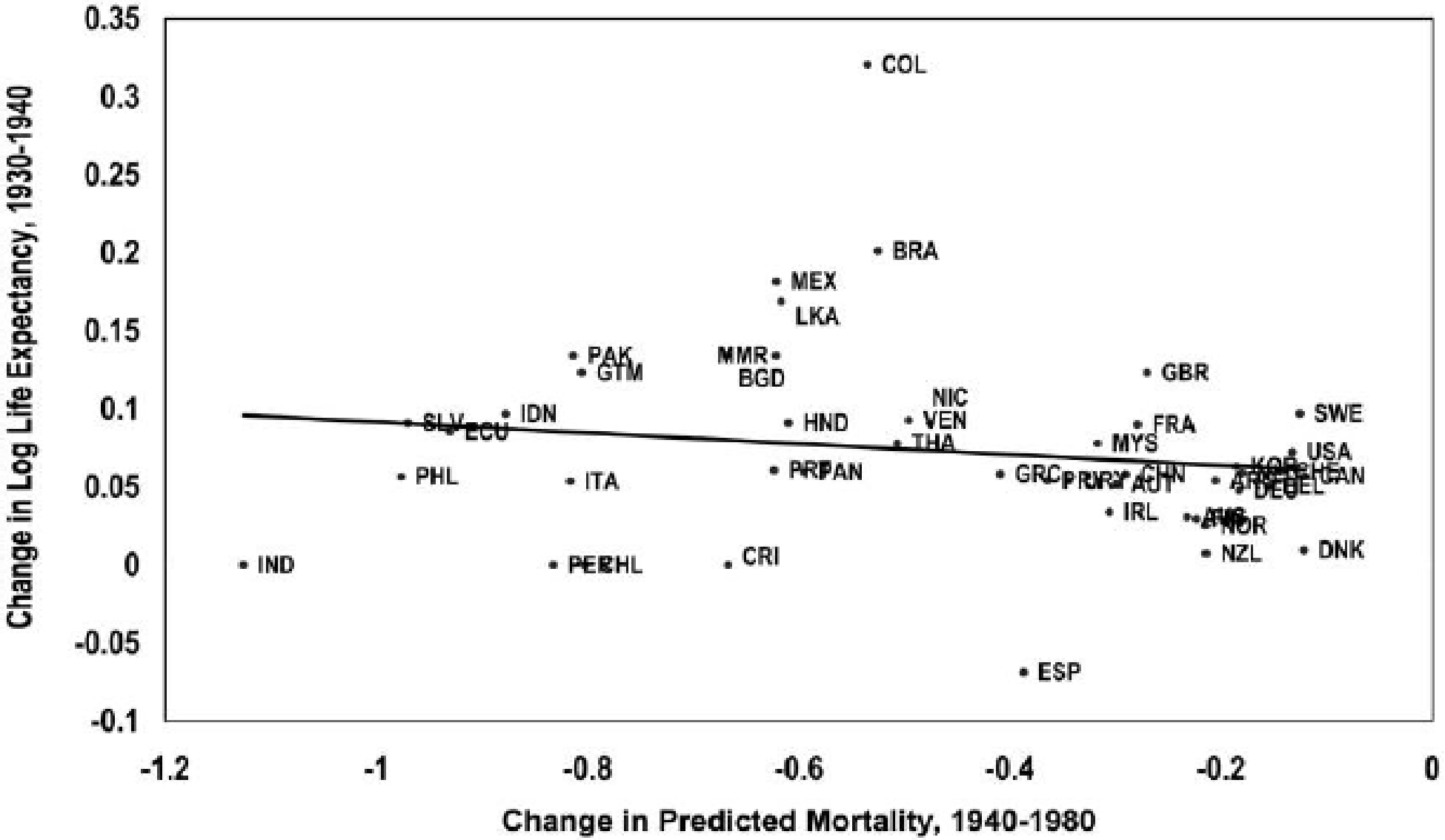


FIG. 6.—Change in log life expectancy, 1930–40, and change in predicted mortality, 1940–80, base sample.

Results

- The instrumented changes in life expectancy have a fairly large effect on population (**Figure 7**).
  - A 1% increase in life expectancy is related to an approximately 1.7–2% increase in population over a 40–60-year horizon.
- However, they find no statistically significant effect on total GDP (**Figure 8**).
- More important, GDP per capita and GDP per working age population show relative declines in countries experiencing large increases in life expectancy.
  - Overall, the increases in life expectancy (and the associated increases in population) appear to have reduced income per capita.
- There is no evidence that the increase in life expectancy led to faster growth of income per capita or output per worker.
  - This evidence casts doubt on the view that health has a first-order impact on economic growth.

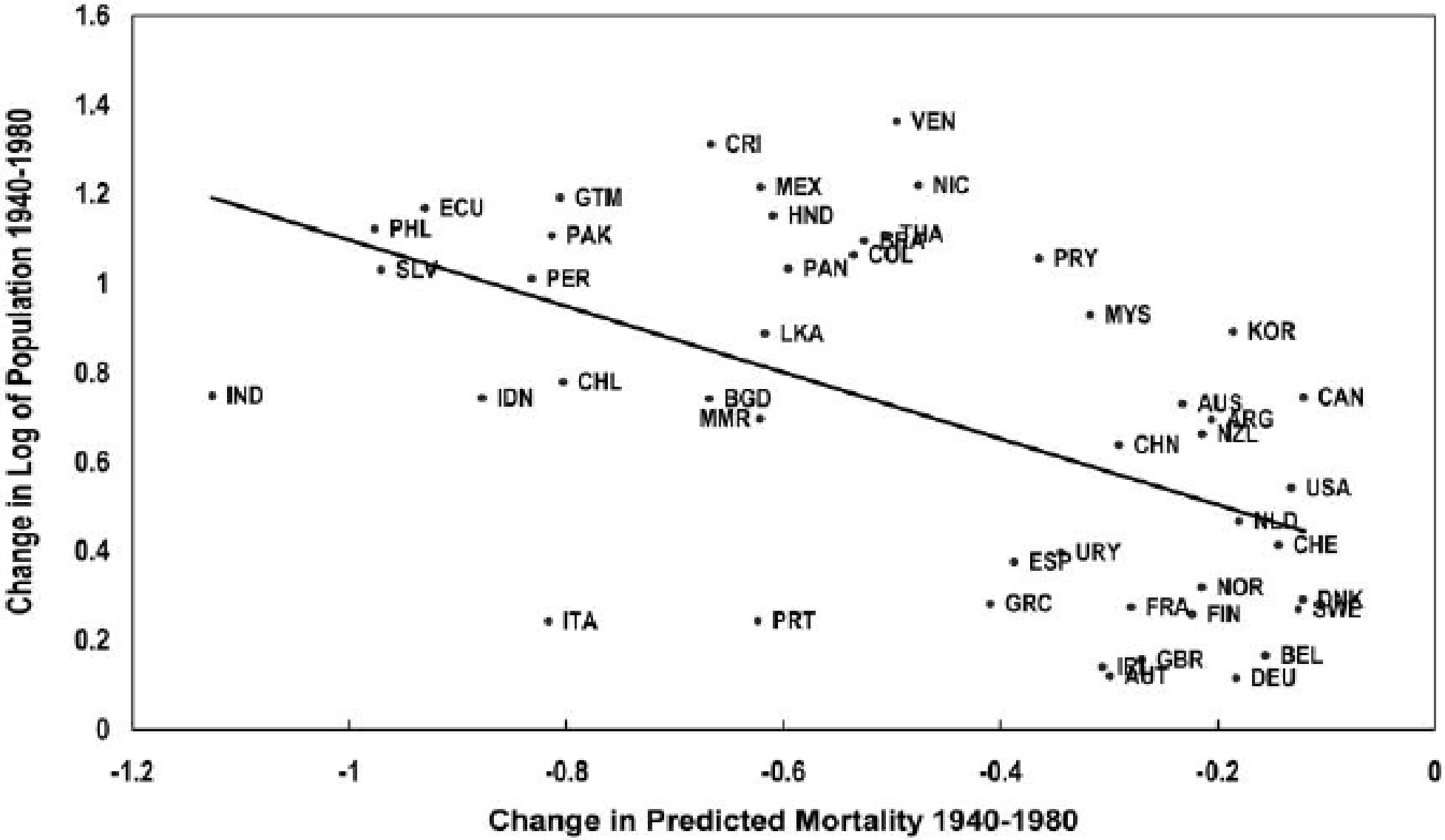


FIG. 7.—Change in log of population and change in predicted mortality, 1940–80, base sample.

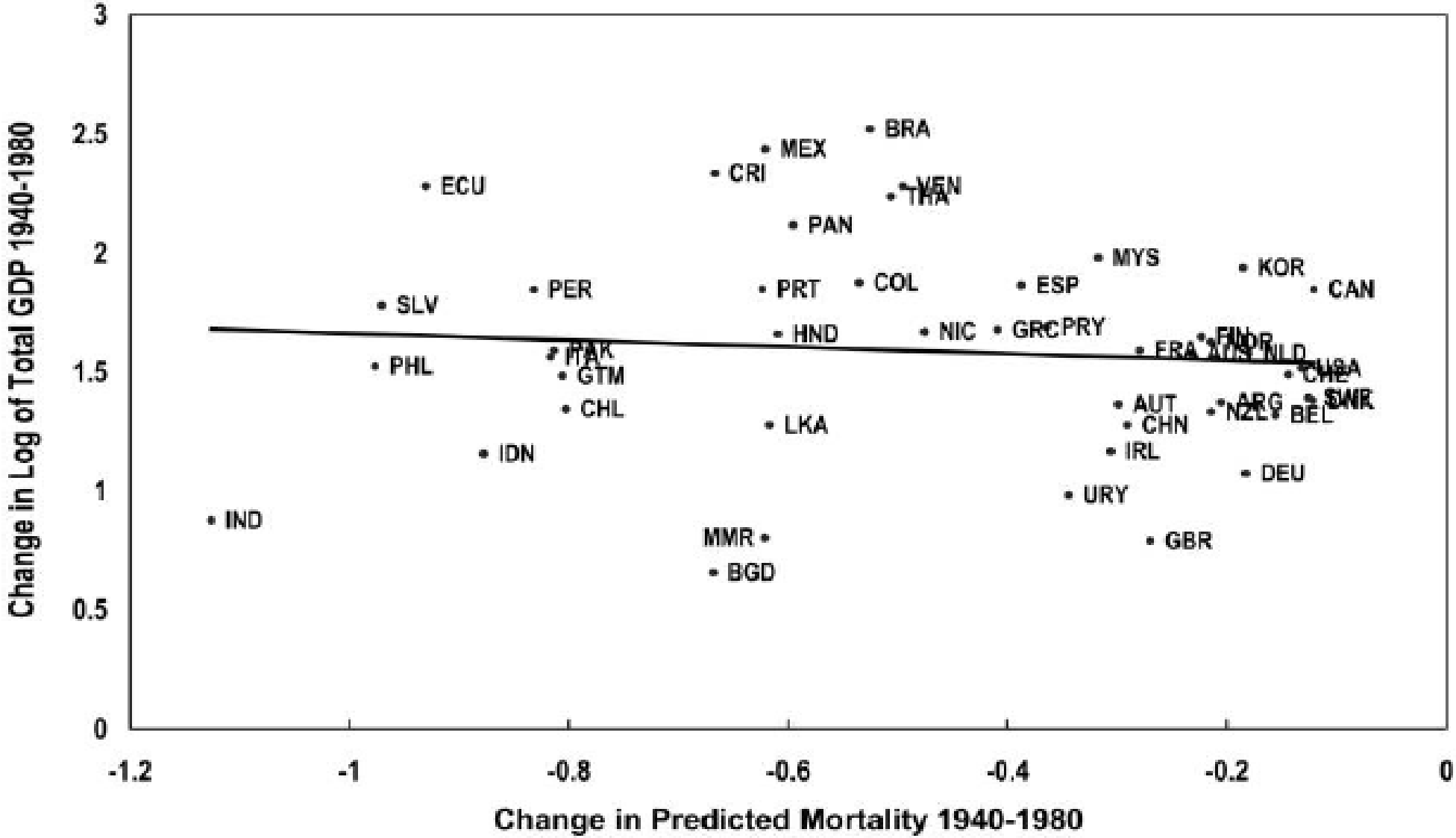


FIG. 8.—Change in log of total GDP and change in predicted mortality, 1940–80, base sample.

- The most natural interpretation of the results comes from neoclassical growth theory.
- Increased life expectancy raises population, which initially reduces capital-to-labor and land-to-labor ratios, thus depressing income per capita.
- This initial decline is later compensated by higher output as more people enter the labor force and as more capital is accumulated.
- This compensation can be complete and may even exceed the initial level of income per capita
  - if there are significant productivity benefits from longer life expectancy.
- Yet, the compensation may also be incomplete
  - if the benefits from higher life expectancy are limited, and
  - if some factors of production, for example, land, are supplied inelastically.

3.3 Almond (2006)

- This paper uses the 1918 influenza pandemic in the US as a natural experiment for testing the fetal origins hypothesis (Barker 1992).
- According to the fetal origins hypothesis, certain chronic health conditions can be traced to the course of fetal development.
  - Randomized experiments with animals have supported the hypothesis.
  - Its relevance for humans remains controversial because of obstacles to evaluation.
    - Omitted factors, such as genetic endowments, may bias nonexperimental studies.
    - There is the inherent difficulty of detecting delayed effects, particularly when the period of latency is long.

- The 1918 influenza pandemic presents an exceptional opportunity to evaluate effects of the prenatal environment using U.S. Census data.
  - 25 million persons contracted the debilitating influenza strain and survived.
  - Some of the highest infection rates were among women of childbearing age,
    - one-third of whom contracted influenza.
  - As census micro data identify both the place and quarter of birth of respondents,
    - these can be linked to the timing and geographic variation in influenza infection.

- Two distinct features of the pandemic limit the scope for omitted variables bias.

1. The pandemic struck without warning in October 1918 and had largely dissipated by the beginning of 1919 (**Figures 1a and 1b**).

   $\Rightarrow$ Cohorts born just months apart experienced very different in utero conditions.

   – This presents a severe test of the fetal origins hypothesis since

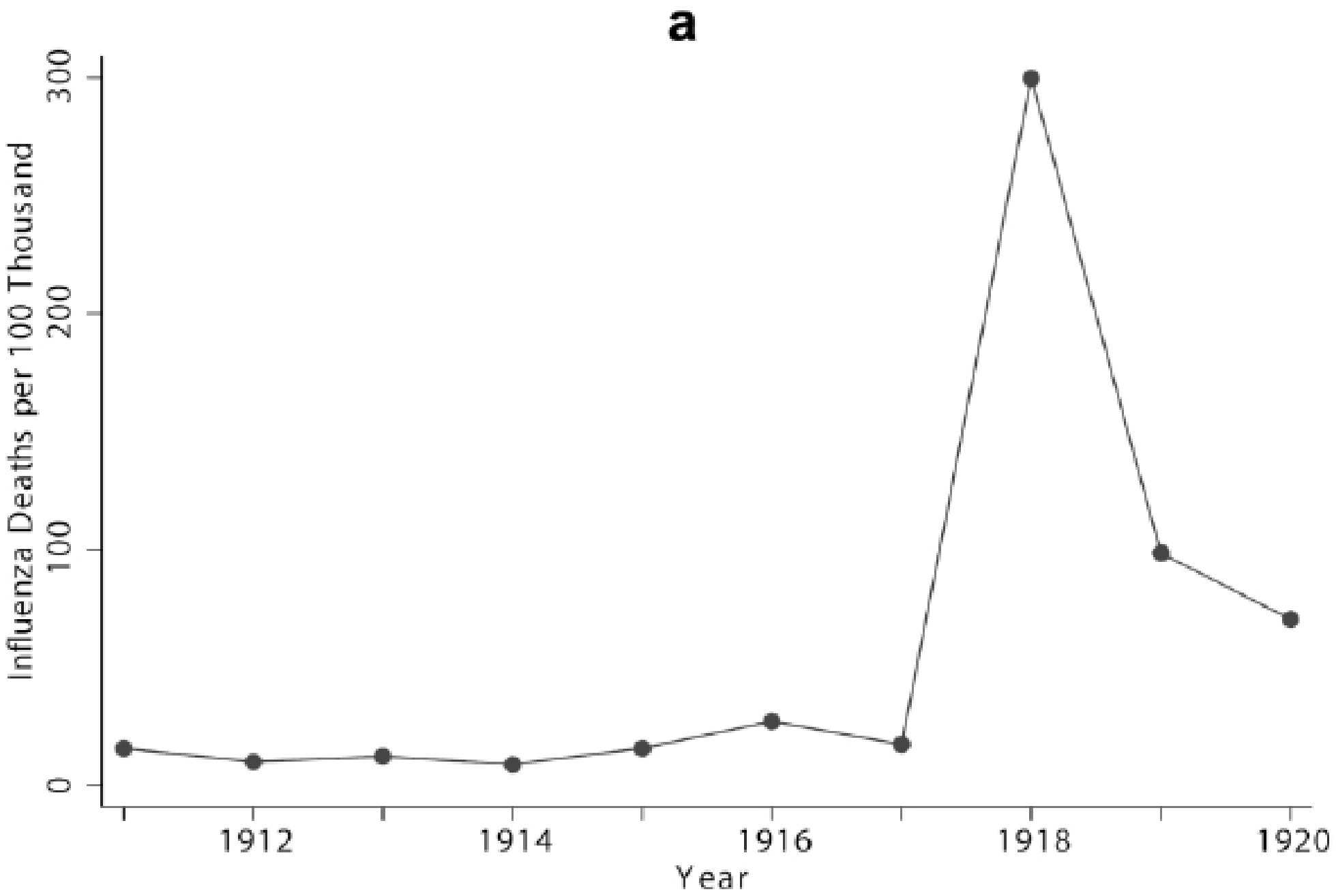
      ◦ the design generates sharp predictions for differences in adult outcomes among individuals born within months of one another.

2. The severity of the pandemic varied widely and idiosyncratically across states.

      ◦ Pregnant mothers in Kansas, for example, experienced more than 10 times the increase in mortality rates than mothers in Wisconsin.

   – This second approach uses geographic variation to identify within-cohort differences in fetal exposure to the pandemic.

      ◦ In order to bias estimates, omitted factors would have to follow the same abrupt and idiosyncratic patterns as the pandemic.


a
Influenza Deaths per 100 Thousand
0
100
200
300
1912
1914
1916
1918
1920
Year

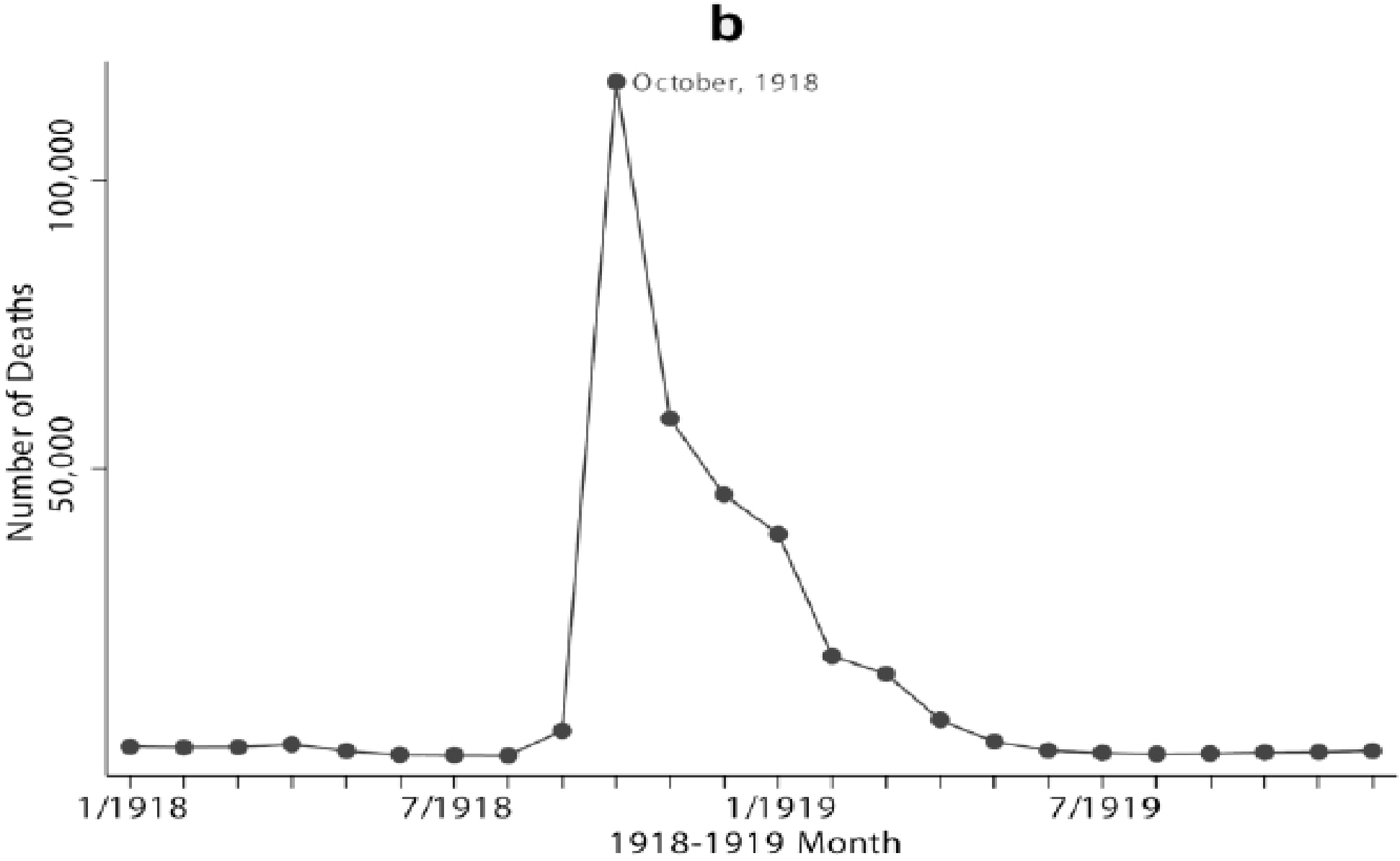


FIG. 1.—U.S. influenza deaths: *a*, by year; *b*, by month

Outcome Differences by Birth Cohort

- Almond (2006) presents two types of evidence.
  1. The raw data are displayed in a series of figures.
  2. Deviations of census outcomes from smooth cohort trends are estimated systematically for cohorts born between 1912 and 1922 as

$$y_i^c = \beta_0 + \beta_1 \cdot I\left(YOB = 1919\right) + \beta_2 \cdot YOB + \beta_3 \cdot YOB^2 + \epsilon_i,$$

     - y_i^c denotes the census outcome for individual i in year c,
     - $I\left(\cdot\right)$ denotes the indicator function,
     - YOB denotes birth year,
     - β_1 measures the departure of outcomes for the 1919 birth cohort from the quadratic cohort trend.

- Estimates for β_1 are reported in **Tables 2, 3, and 4** for men, women, and nonwhites.

TABLE 2
DEPARTURE OF 1919 MALE BIRTH COHORT OUTCOMES FROM 1912–22 TREND

	CENSUS YEAR		
OUTCOME	1960	1970	1980
High school graduate	−.021***	−.020***	−.014***
	[.005]	[.003]	[.003]
Years of education	−.150***	−.176***	−.117***
	[.038]	[.023]	[.019]
Total income	−573*	−1,236***	−1,065***
	[295]	[253]	[191]
Wage income	−812***	−875***	−688***
	[261]	[233]	[179]
Poor (below 150% of the poverty level)	.010**	.009***	.006***
	[.005]	[.002]	[.002]
Neighbors' income (N = 102,948)		−875***	
		[197]	
Socioeconomic status (Duncan's socioeconomic index)	−.640**	−.808***	−.816***
	[.259]	[.157]	[.137]
Disability limits work		.006***	.005**
		[.002]	[.002]
Disability prevents work		.004***	.001
		[.001]	[.002]
Years of disability		.092***	
		[.025]	
Social Security income		1	83***
		[2]	[19]
Welfare income		12**	17**
		[6]	[7]
Observations	114,031	308,785	471,803

TABLE 3
1912–22 Census Outcomes among Women (Census Years 1960, 1970, and 1980)

	Sample Mean			1919 Cohort Departure		
	1960	1970	1980	1960	1970	1980
High school graduate	.504 [.500]	.523 [.499]	.542 [.498]	−.028*** [.005]	−.021*** [.003]	−.015*** [.002]
Years of education	10.5 [3.0]	10.7 [3.0]	10.8 [3.2]	−.163*** [.032]	−.123*** [.019]	−.071*** [.015]
Total income	8,282 [12,718]	13,372 [18,138]	13,385 [16,952]	244* [135]	−139 [112]	−235** [93]
Wage income	15,682 [12,019]	21,212 [15,926]	6,911 [13,405]	50 [190]	−90 [138]	−62 [76]
Poor (below 150% of the poverty level)	.284 [.451]	.170 [.376]	.231 [.421]	.012** [.005]	.009*** [.002]	0 [.002]
Neighbors' income (N = 111,057)		51,007 [17,418]			−449** [189]	
Socioeconomic status (Duncan's socioeconomic index)	22.5 [24.2]	25.7 [25.1]	19.8 [25.1]	−.176 [.253]	−.461*** [.155]	−.470*** [.124]
Disability limits work		.066 [.247]	.240 [.427]		0 [.002]	.002 [.002]
Disability prevents work		.078 [.268]	.184 [.388]		.004** [.002]	.003 [.002]
Years of disability		1.2 [3.6]			.028 [.021]	
Social Security income		50 [299]	2,460 [3,583]		1 [2]	−50*** [13]
Welfare income		139 [1,087]	269 [1,360]		18** [7]	11* [7]
Observations	118,471	331,985	550,108	118,471	331,985	550,108

TABLE 4
1912–22 Census Outcomes among Nonwhites (Census Years 1960, 1970, and 1980)

	Sample Mean			1919 Cohort Departure[a]		
	1960	1970	1980	1960	1970	1980
High school graduate	.224 [.417]	.246 [.431]	.276 [.447]	−.032*** [.010]	−.026*** [.006]	−.013*** [.005]
Years of education	8.1 [3.8]	8.5 [3.7]	8.5 [4.0]	−.241*** [.086]	−.225*** [.051]	−.116*** [.043]
Total income	13,641 [14,718]	18,839 [20,249]	16,013 [18,625]	38 [281]	−441* [266]	−574*** [217]
Wage income	17,006 [13,338]	23,484 [18,390]	10,047 [17,398]	−127 [319]	−430 [294]	−500** [206]
Poor (below 150% of the poverty level)	.598 [.490]	.398 [.489]	.422 [.494]	.024** [.011]	.01 [.007]	.004 [.006]
Neighbors' income (N = 20,228)		0 [0]			175 [346]	
Socioeconomic status (Duncan's socioeconomic index)	15.7 [17.2]	18.4 [19.2]	15.3 [20.5]	−.415 [.384]	−.866*** [.264]	−.364 [.224]
Disability limits work		.096 [.295]	.358 [.479]		−.003 [.004]	.009** [.005]
Disability prevents work		.120 [.325]	.276 [.447]		.009** [.004]	.009* [.005]
Years of disability		1.7 [4.2]			.033 [.057]	
Social Security income		70 [356]	2,368 [3,842]		1 [5]	−2 [35]
Welfare income		427 [1,937]	705 [2,220]		51* [29]	20 [26]
Observations	23,008	60,390	104,391	23,008	60,390	104,391

Educational Attainment

- **Figure 3** plots the average schooling of men and women born in the US by year of birth from the 1960 Census.
  - There is a strong upward trend in educational attainment for the 1912-1922 cohorts.
  - The 1919 birth cohort lies off this steady trend and received approximately one and a half months less schooling than the cohort trend would predict.
  - Since not all pregnant mothers contracted influenza prior to delivery,
    - this deviation is accounted for by a larger treatment effect among the treated.
  - With the estimated one-third infection rate among women of childbearing age,
    - education falls approximately five months for those with infected mothers.

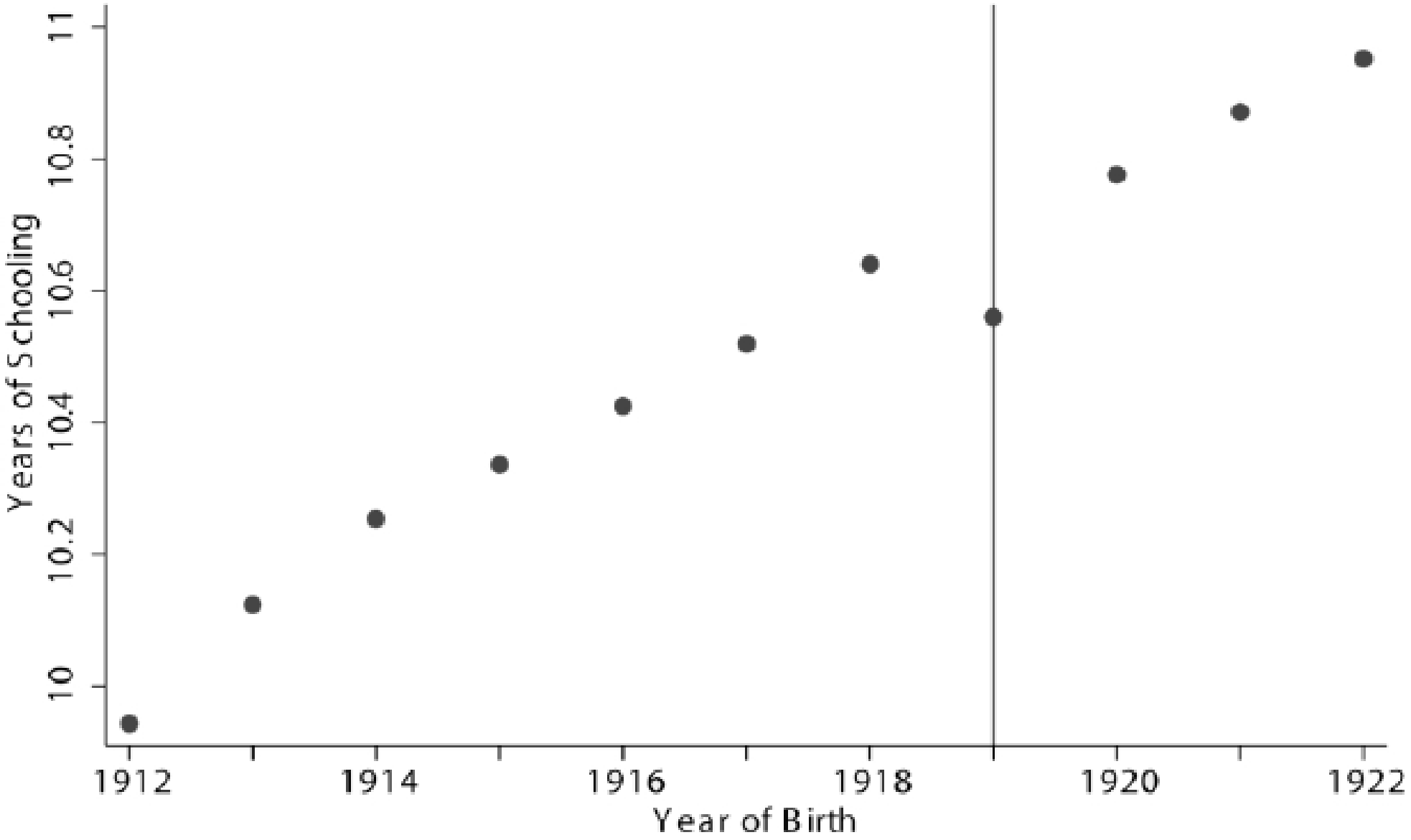


FIG. 3.—1960 average years of schooling: men and women born in the United States

- **Figure 4** again plots educational attainment, using 1970 Census data and adding two pieces of information.
  - The departure from trend exists for both men and women,
  - A primary “node” of the education effect was whether high school was completed.
- The 1919 cohort was 4-5% less likely to complete high school than the cohort trend would predict (13-15% among the treated).
- The deterioration of educational attainment for men, women, and nonwhites is significant at the 1% level (**Tables 2, 3, and 4,** respectively).

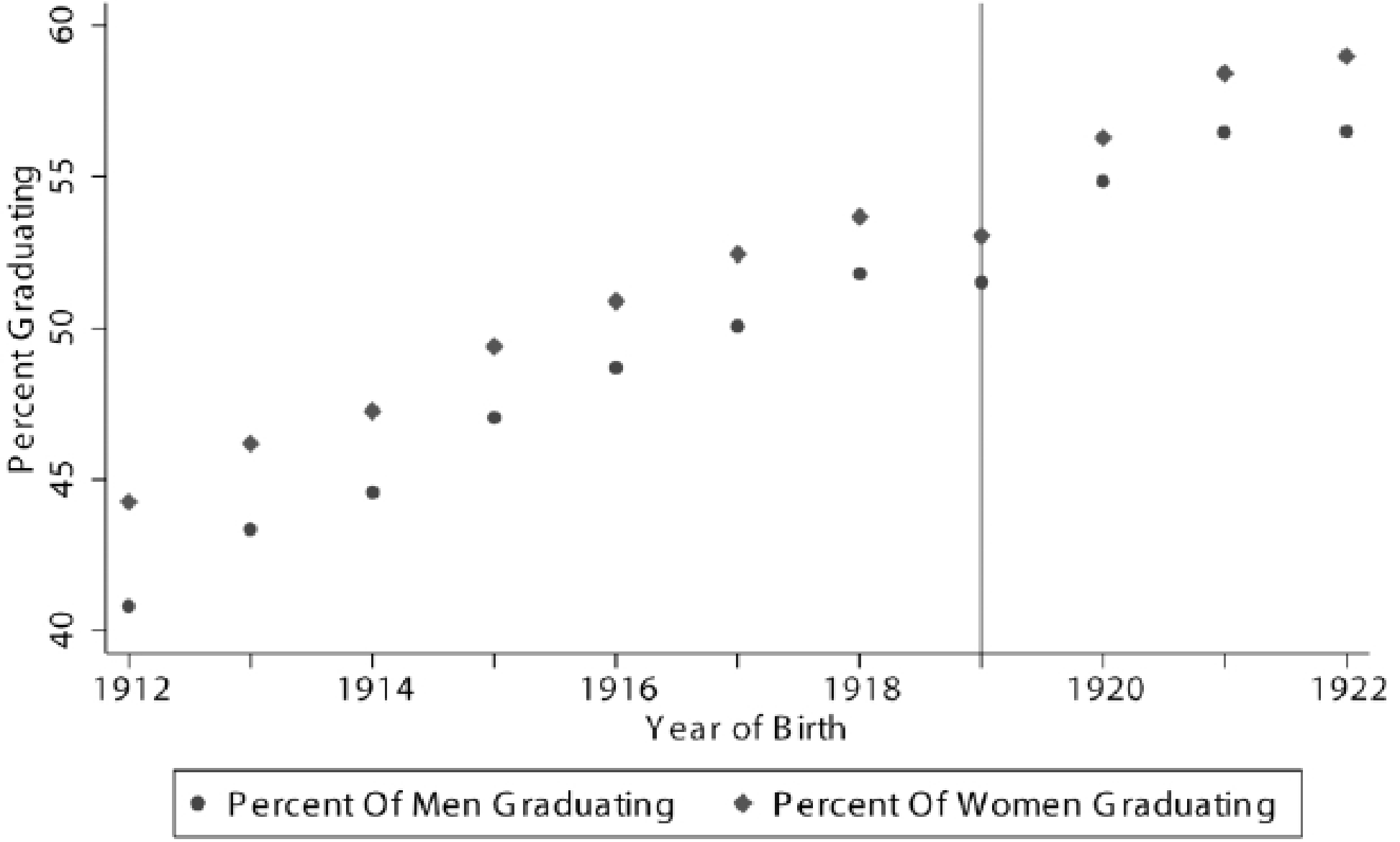


FIG. 4.—1970 high school graduation: by year of birth

Wages and Disability

- Annual wage income is $700–$900 lower (2005 dollars) for men born in 1919 across the three censuses, or approximately $2,500 (5–9%) lower for the sons of infected mothers.
- Part of the income reduction is presumably attributable to the reduction in education noted above.
  - The decrease in wages can be decomposed into that caused by shortened schooling versus other impacts of poor fetal health.
  - The gross effect associated with decreasing schooling one year is to reduce wage income from 10 to 25%.
  - Therefore, as much as half of the total wage effect is apparently due to noneducation factors.

- Disability status appears to contribute to the wage effect.
- **Figure 6** plots the share of cohorts reporting a physical disability that limited or prevented work in 1970.
  - A discontinuous increase is readily apparent for the 1919 birth cohort.
  - Men are 6% more likely to have a work-limiting disability and 8% more likely to have a work-preventing disability if born in 1919 (17% and 25% among the infected, respectively).
- **Figure 2** plots by quarter of birth the share of men prevented from working by a physical disability in 1980.
  - A clear departure from the downward trend is evident for men born between January and September of 1919.
  - These birth cohorts were in utero at the height of the pandemic;
    - They are estimated to have 20% higher disability rates at age 61 as a result of fetal influenza exposure.

FIG. 6.—1970 male disability rate: physical disability limits or prevents work

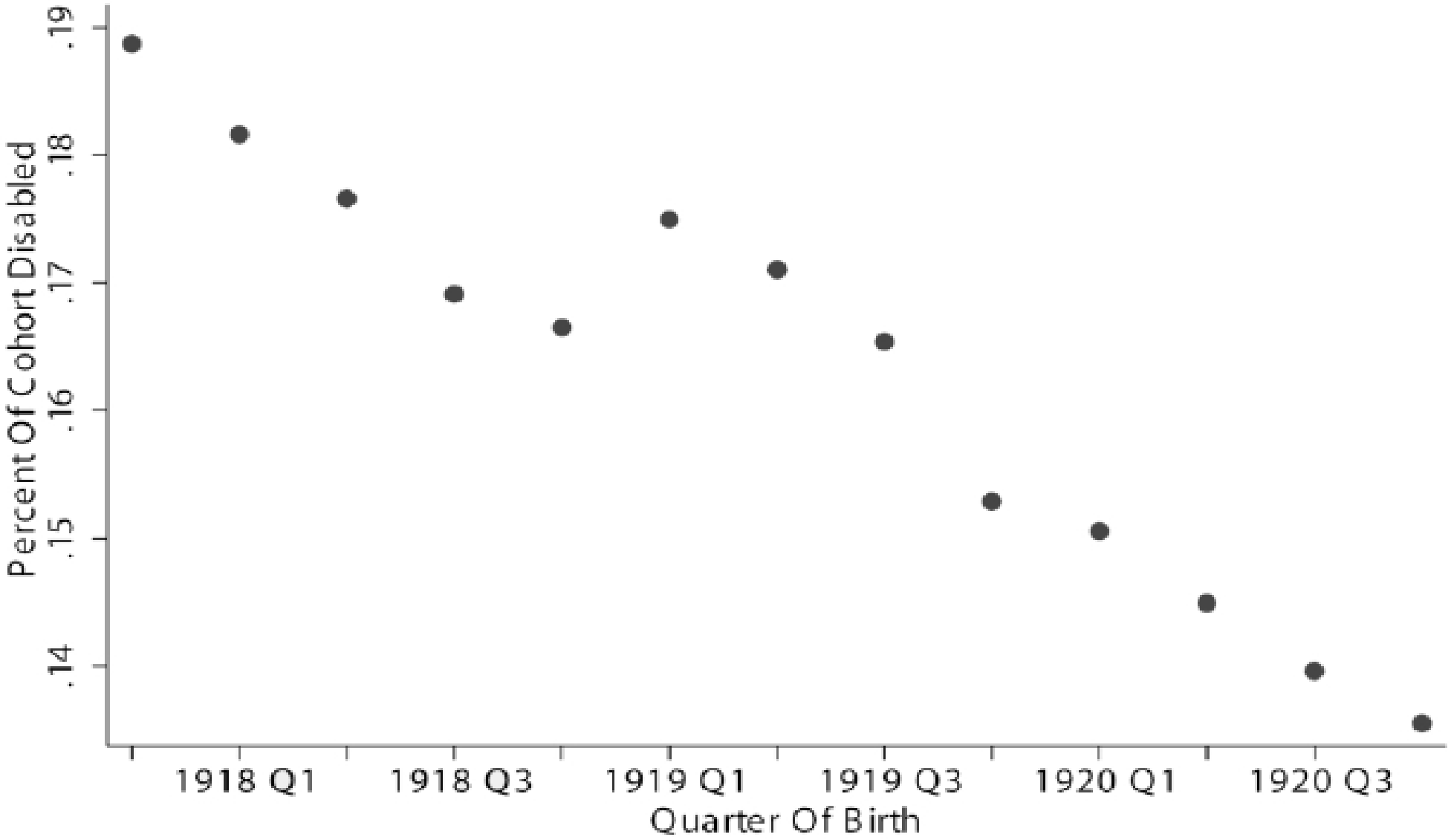


FIG. 2.—1980 male disability rates by quarter of birth: prevented from work by a physical disability.

Outcome Differences by State of Birth

- Here the primary identification approach is to utilize geographic variation: differences in the severity of the pandemic.
- Adult outcomes in the US Census, y_i, can be estimated as a function of maternal influenza infection:

$$y_i = \beta_0 + \beta_1 \psi_s^{yob-1} + \gamma^{yob} + \lambda_s + \epsilon_i,$$

  - ψ denotes the influenza infection rates among mothers,
  - s denotes the state of birth,
  - $yob - 1$ denotes the year prior to the birth year.
    - The year preceding the birth year is used to capture the in utero health conditions.
  - Year of birth fixed effects, γ^{yob}, remove the average outcome differences related to birth year.
  - λ_s accounts for the effect of fixed state-level factors.

- The first row of **Table 5** reports the estimates for ψ for each outcome variables.
  - The term ψ enters in the expected direction for each outcome.
  - When one-third is used as the average maternal infection rate for the 1919 cohort,
    - infection is estimated to reduce schooling by $0.756 \times \frac{1}{3}$ year, or 0.25 year.
  - The likelihood of graduating from high school is estimated to fall approximately 0.03 percentage points for the 1919 cohort.
  - Income is estimated to fall approximately 6 percent.
  - Poverty increases approximately 1.5 percentage points.
  - Socioeconomic status falls nearly one index point for the 1919 cohort.

TABLE 5
MEN BORN 1918–20: 1960 STATE OF BIRTH FIXED-EFFECTS RESULTS

	INDEPENDENT VARIABLE			
DEPENDENT VARIABLE	Maternal Infection (ψ)	Infant Mortality Rate	Attrition	State of Residence Dummies
Years of education	−.756***			No
	[.259]			
	−.793***	−.0059*		No
	[.229]	[.003]		
	−.818***	−.0553*	−.426	No
	[.228]	[.0308]	[.318]	
	−.759***	−.0329	−.392	Yes
	[.233]	[.0313]	[.314]	
High school graduate	−.101***			No
	[.070]			
	−.103***	−.0003*		No
	[.0355]	[.00005]		
	−.109***	−.0026	−.091*	No
	[.039]	[.0051]	[.050]	
	−.105***	−.00046	−.0908*	Yes
	[.0378]	[.0052]	[.0499]	
Log income	−.165***			No
	[.0719]			
	−.176***	−.0018**		No
	[.060]	[.00086]		
	−.172***	−.0181*	.0629	No
	[.062]	[.0086]	[.0557]	
	−.166***	−.0139	.0707	Yes
	[.0623]	[.0085]	[.0599]	

TABLE 5

MEN BORN 1918–20: 1960 STATE OF BIRTH FIXED-EFFECTS RESULTS

DEPENDENT VARIABLE	INDEPENDENT VARIABLE			
	Maternal Infection (ψ)	Infant Mortality Rate	Attrition	State of Residence Dummies
Poverty status (below 150% of poverty level)	.0424			No
	[.0259]			
	.0461**	.00059		No
	[.224]	[.00040]		
	.0429*	.0064*	−.0529	No
	[.0233]	[.0039]	[.0398]	
	.0386	.0041	−.0533	Yes
	[.0255]	[.0040]	[.0397]	
Socioeconomic status (Duncan's socioeconomic index)	−2.711			No
	[1.735]			
	−2.806*	−.0150		No
	[1.635]	[.03057		
	−2.863*	−.142	−.9441	No
	[1.665]	[.307]	[2.372]	
	−2.721	−.023	−1.075	Yes
	[1.764]	[.298]	[2.361]	
Observations	16,566	16,566	16,566	

Conclusion

- Data from the 1960–80 decennial U.S. Census indicate that cohorts in utero during the 1918 influenza pandemic displayed
  - reduced educational attainment, increased rates of physical disability, lower income, lower socioeconomic status, and higher transfer payments compared with other birth cohorts.
- These results indicate that investments in fetal health can increase human capital.
  - Investments targeting fetal health may have higher rates of return than more traditional investments, such as schooling.
  - Public policies that improve fetal health may therefore have additional “multiplier” benefits that are not accounted for in conventional cost-benefit calculations.

Productivity Effects of Health: Summary

- There is a strong relationship between health and productivity at the micro level.
  - Role of Micro-nutrients (iodine, iron, and so on) seems to be particularly important.
- Impact of nutrition in utero and in childhood may be much larger than later in life, since
  - it may cause permanent damage on health (so impact would be multiplied by years of life), and
  - through amplification impacts through education.
- Need to go back to thinking in more detail about what is happening within the household:
  - if nutrients are indeed shared more unequally in the household when there is a shock (as the Dasgupta and Ray (1986) model would suggest),
    - this may create a space for a inter-generational poverty trap to emerge.

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