Inequality in Health

Lecture VI: Early Life Conditions

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Outline

Recap of Last Lecture

Recap of Last Lecture

- Human Ageing is best described as an accumulation of **health deficits**.
- A serial-parallel system has **redundancy**, which implies **ageing**.
- The Dalgaard and Strulik (2014) model incorporate these insights in an economic model.
- Individuals invest in health to reduce deficit accumulation.
- Model can predict the trajectory of health quite well.
- Implication for Preston curve: largely reflects causation running from income to health.

Introduction

Introduction

- Well-documented **association** between **health** in early life and health in adulthood.
- Early-life health insults may affect **economic** outcomes in adulthood:
  1. **Direct** effects: permanent cognitive impairments.
  2. **Indirect** effects: poor health in adulthood $\Rightarrow$ labour supply and productivity $\Downarrow$.
- Increasing attention to the determinants of health even **before** birth: **fetal conditions** have large effects on later-life outcomes.

The Fetal Origins Hypothesis

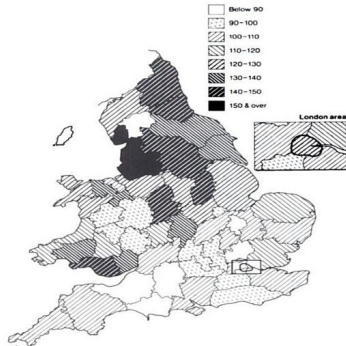# The Barker Hypothesis

Infant mortality rates, 1901-1910

CHD mortality rates, 1968-1978
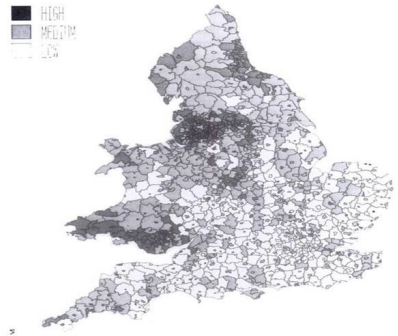
Figure 1. Association between IMR and CVD.

Source: Barker (1998).

The Fetal Origins Hypothesis

- **Fetal origins hypothesis** (Barker, 1990).
- The *in utero* environment "programs" some characteristics in the fetus that can lead to:
    - Worse health in the **post-neonatal** period (preterm birth, low birth weight) and in **childhood**;
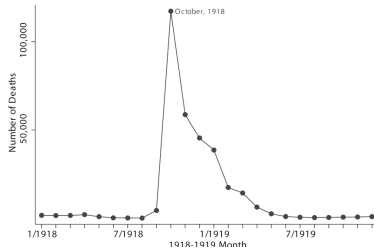   - Increased risk of chronic diseases in **adulthood** (cardiovascular diseases, diabetes, hypertension).
- **Shocks** suffered in utero are the main **triggers** to metabolic changes in the fetus:
    - **Epidemics**
    - **Natural disasters**
    - **Extreme weather** conditions/air pollution
    - **Nutritional deprivation**.

In-Utero Influenza Exposure

(a) Influenza deaths by month
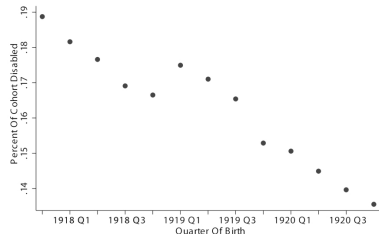
(b) Male disability rates in 1980.

Figure 2. Effects of in utero exposure to 1918–19 influenza pandemic.

Source: Almond (2006).

Rainfall in Early Life
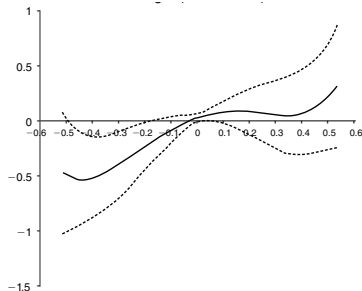
(a) Adult height (cm)
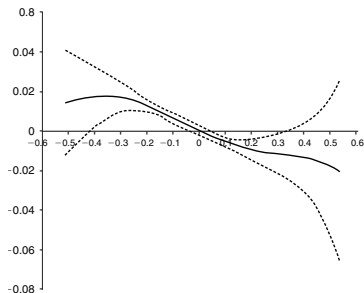
(b) Self-reported health (poor/very poor)

Figure 3. Outcomes on early life rainfall shocks (deviations of log rainfall by birth district and year) for Indonesian adults.

Source: Maccini and Yang (2009).

External Shocks as a Proxy for Early-Life Conditions

- **Hurricanes** ⇒ maternal **stress** ⇒ worse **newborn health** (Currie and Rossin-Slater, 2013).
- **Radioactive downfall** (Chernobyl) in utero ⇒ worse **educational outcomes** (Almond et al., 2009).
- **Famine** in utero ⇒ lower **employment**, higher **hospitalisation risk** after age 50 (Scholte et al., 2015).
- **Extreme floods** in utero ⇒ lower **birth weight**, lower **cognitive abilities** (Rosales-Rueda, 2018).

Empirical Application I: Molina (2021)

Pollution, Ability, and Investment Responses

- Molina (2021) investigates
  1. how shocks to **cognitive ability** affect **schooling decisions**
  2. how **labour market conditions** result in **gender-specific responses** to shocks.
- Strategy: **thermal inversion** (during pregnancy) used as exogenous variation affecting cognitive ability.
- Main findings:
  - Women face lower high school completion and income as response to adverse shocks.
  - Men do not react to in utero pollution exposure.
- Reasons:
  - Women more likely to sort into **white-collar** occupations
  - **Schooling** and **ability** are more **complementary** in white- than blue-collar occupations.

Theoretical Model

- Wage $(W_k(E, \theta; \beta_k))$ is a function of
    - Educational attainment (E)
    - Ability endowment (θ)
    - Occupation $(k;\ k = w$ for white-collar, $k = b$ for blue-collar, and $k = n$ for no occupation)
- We assume: $\frac{\partial W_k}{\partial \theta} > 0$, $\frac{\partial W_k}{\partial E} > 0$, $\frac{\partial^2 W_k}{\partial \theta^2} < 0$, and $\frac{\partial^2 W_k}{\partial E^2} < 0$.
- And further: $\frac{\partial^2 W_w}{\partial E \partial \theta} > \frac{\partial^2 W_b}{\partial E \partial \theta}$, i.e., schooling and ability are more complementary in white-collar jobs.
- Opportunity cost of schooling $c(E, \theta; \alpha)$ with $\frac{\partial c}{\partial E} > 0$ and $\frac{\partial^2 c}{\partial E^2} > 0$

Theoretical Model

- Write the maximization problem as

$$\max_E p_{jg}\left(E,\theta\right) q_{jg}\left(E,\theta\right) W_w\left(E,\theta;\beta_w\right) \tag{1}$$

$$+ \left(1 - p_{jg}\left(E,\theta\right)\right) q_{jg}\left(E,\theta\right) W_b\left(E,\theta;\beta_b\right) \tag{2}$$

$$+ \left(1 - q_{jg}\left(E,\theta\right)\right) W_n\left(E,\theta;\beta_n\right) - c\left(E,\theta;\alpha\right) \tag{3}$$

where

q_{jg} probability of entering labour force,

p_{jg} probability of white-collar job conditional on labor force participation,

j place and time indicator, and

g gender.

Theoretical Model

- Simplify the model defining $p_{jg} = \bar{p}_{jg} + p(E, \theta)$ and $q_{jg} = \bar{q}_{jg} + q(E, \theta)$.
- Thus, gender and location only matter for **levels** of p and q.
- Using the implicit function theorem, optimal schooling will respond to a positive shock θ as

$$\frac{dE^*}{d\theta} = -\frac{A}{B} \tag{4}$$

where B is negative by assumption and

$$A = \bar{p}_{jg}\bar{q}_j\frac{\partial^2 W_w}{\partial E \partial \theta} + (1 - \bar{p}_{jg})\bar{q}_j\frac{\partial^2 W_b}{\partial E \partial \theta} \tag{5}$$

$$+ (1 - \bar{q}_j)\frac{\partial^2 W_n}{\partial E \partial \theta} - \frac{\partial^2 c}{\partial E \partial \theta} \tag{6}$$

Theoretical Model

- If $\frac{\partial^2 W_w}{\partial E \partial \theta} > \frac{\partial^2 W_b}{\partial E \partial \theta}$ holds, individuals more likely to get a white-collar job (higher p_{jg}, mostly women) will increase optimal schooling more in response to a positive shock in θ.

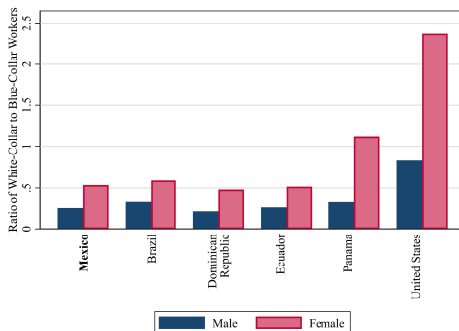Figure 4. White-Collar to Blue-Collar Ratios Across Countries, by Gender.

Source: Molina (2021).

Background: Thermal Inversion

- Normally, air temperature falls with altitude.
- In case of **thermal inversions**, a warm layer of air is above cooler air.
- Hence, pollutants released near the surface are trapped.
- Thus, thermal inversions can negatively impact air quality.
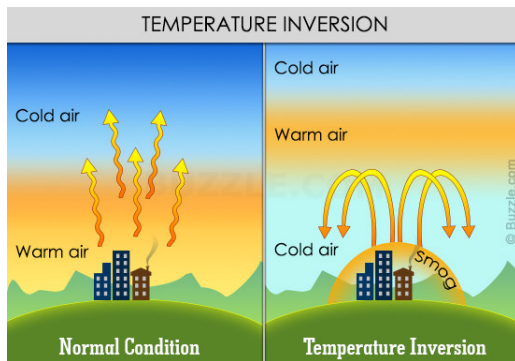
Figure 5. Thermal Inversion.

Data

- The individual-level information is based on three waves (2002, 2005, and 2009) of the **Mexican Family Life Survey**.
  - Raven's test score is used as a measure of **cognitive ability**.
  - **Height Z-Scores** indicate physical health.

Figure 6. Raven's Progressive Matrices Test

- Thermal inversion data from the North American Regional Reanalysis
- Weather data from Mexico's National Meteorological Service.
- The 1990, 2000, and 2010 Mexican censuses used to obtain **occupation information**.

Data

Table 1. Summary Statistics.

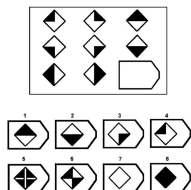| Variable Name	Female			Male		
	Mean	S.D.	N	Mean	S.D.	N
Outcome Variables						
Raven's test score (% correct)	0.55	0.229	5455	0.56	0.226	4865
Height (cm)	155.20	7.722	5506	166.06	10.27	4892
Years of schooling	9.52	3.075	5634	9.20	3.074	5081
Annual income	23473.04	22428.0	998	29745.26	72818.3	2157
Control Variables						
Mother's Education	6.00	3.853	5204	6.36	3.804	4566
Father's Education	6.34	4.279	4832	6.69	4.226	4258
Age for Raven's Test variable	17.24	3.319	5455	17.12	3.398	4865
Age for height variable	20.38	4.491	5506	19.86	4.507	4892
Age for schooling variables	20.45	4.424	5634	19.94	4.463	5081
Age for income variable	22.61	3.656	998	22.37	3.715	2157

	Full Sample					
Dependent Variables	Mean	SD	10th pctile	Median	90th pctile	N
Average monthly inversions during trimester 1	18.09	8.206	5.93	19.23	28	10848
Average monthly inversions during trimester 2	17.93	8.235	5.69	18.94	28	10848
Average monthly inversions during trimester 3	17.80	8.288	5.54	18.94	28	10848

Source: Molina (2021).

Empirical Strategy

- Molina estimates regressions for individuals i born in municipality j in year y and month m and survey wave w of the following form:

$$Y_{ijymw} = \alpha_0 + \sum_{k=-7}^{4} \beta_k I_{jym}^{3k} + \sum_{k=-7}^{4} \alpha_k' W_{jym}^{3k} + \gamma' X_i + \mu_j \quad (7)$$

$$+ (\delta_y \times \nu_w) + \eta_m + \epsilon_{ijymw} \quad (8)$$

where

$\quad I_{jym}^{a}$ average number of monthly thermal inversions during three months starting in a,

$\quad W_{jym}^{a}$ a vector of weather controls,

$\quad X_i$ individual-level controls,

$\quad \mu_j$ municipality fixed effects,

$\quad \delta_y \times \nu_w$ wave and age effects, and

$\quad \eta_m$ month fixed effects.

Empirical Strategy

- Several additional specifications (e.g., state-specific trends) are considered.
- Further, pooled as well as gender-specific regressions are estimated.
- Standard errors are clustered at the municipality level.

Results
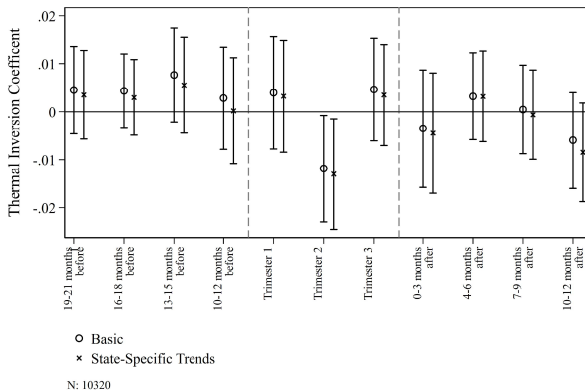
Figure 7. Effects of Pollution on Raven's Test Z-Scores.

Source: Molina (2021).

Results

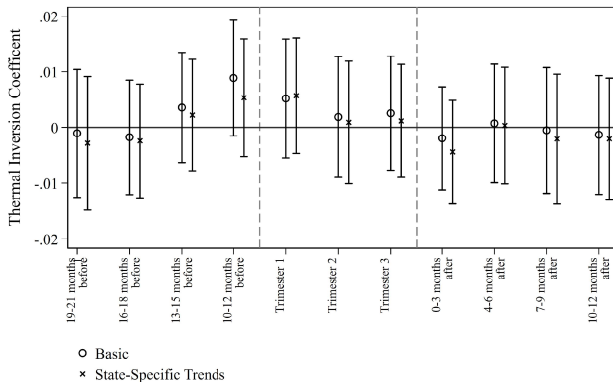
Figure 8. Effects of Pollution on Height Z-Scores.

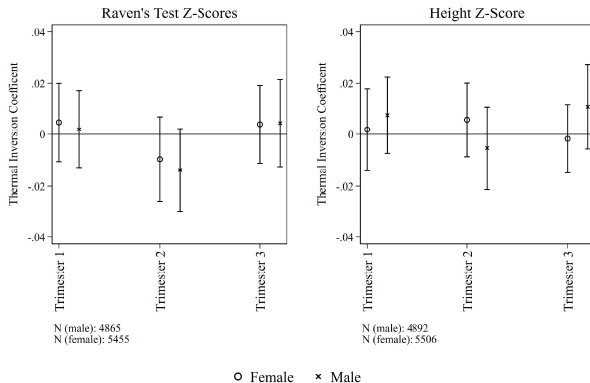*Source: Molina (2021).*

Results

Figure 9. Effects of Pollution on Cognitive and Physical Health, by Gender.

Source: Molina (2021).

Results

Figure 10. Effects of Pollution on Educational Attainment, by Gender.

Source: Molina (2021).
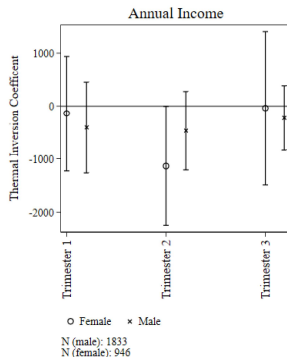
Results

Figure 11. Effects of Pollution on Income, by Gender.

Source: Molina (2021).

Results

Table 2. Effects on High-School Graduation, by White Collar Opportunities.

Average monthly inversions...	HS Completion	HS Completion	HS Completion	HS Completion
Trimester 1	0.00375	0.00462	0.00363	0.00447
	(0.00353)	(0.00534)	(0.00353)	(0.00553)
Trimester 2	-0.00773**	-0.00172	-0.00792***	-0.000896
	(0.00306)	(0.00415)	(0.00299)	(0.00435)
Trimester 3	0.000748	0.000168	0.00179	0.000764
	(0.00308)	(0.00571)	(0.00311)	(0.00579)
Trimester 1	-0.00460	-0.00437	-0.00423	-0.00429
x 1(Male)	(0.00476)	(0.00596)	(0.00478)	(0.00621)
Trimester 2	0.00702*	0.00258	0.00771*	0.00221
x 1(Male)	(0.00393)	(0.00448)	(0.00405)	(0.00483)
Trimester 3	0.00240	0.00185	0.00112	0.000707
x 1(Male)	(0.00429)	(0.00593)	(0.00431)	(0.00584)
Trimester 1		-0.000873		-0.000643
x 1(Predicted white collar proportion in top quartile)		(0.00456)		(0.00476)
Trimester 2		-0.00758**		-0.00891**
x 1(Predicted white collar proportion in top quartile)		(0.00359)		(0.00370)
Trimester 3		0.000228		0.000691
x 1(Predicted white collar proportion in top quartile)		(0.00454)		(0.00455)
N	10715	10572	10715	10572
Dependent variable mean	0.266	0.264	0.266	0.264
Additional Fixed Effects		None		state-by-season, state-by-quadratic-year

Threats to Identification

- **Fertility timing**: no evidence, thermal inversion likely to be exogenous
- **Mortality selection**: no evidence for effects on infant mortality
- Correlates of white collar proportions: no evidence

Conclusion

- In utero exposure to pollution is shown to affect **cognitive abilities** but not physical health.
- Thermal inversions during the second trimester have a significantly negative effect on **high school completion** for **women** only.
- Significantly negative effects on female income are identified but male income appears to be **unaffected**.
- The heterogeneity in effects on economic outcomes is likely driven by **gender-specific labour market opportunities**.

Empirical Application II: Chakravarty et al. (2021)

The Human Capital Legacy of a Trade Embargo

- Chakravarty et al. (2021) investigate
  1. how economic shocks in utero affect **health** and **schooling**
  2. how factors like **access to markets** and **parental discrimination** are affecting the response to the shock.
- Strategy: Exposure to **trade embargo** (during pregnancy) used as exogenous variation.
- Main findings:
  - Decline in live births, driven by female births.
  - Exposed women are more likely to have more education.
  - Infant mortality increases for boys.
- Reasons:
  - **Selection** dominates scarring.
  - **Underreporting** of miscarriages and infant mortality.

Background: 1989 Indian Embargo to Nepal

- **Coercive** Inidian policy measure – disagreements with Nepal gvt.
- Nepal is **landlocked** and depends on India for trade with the world.
- 6th Poorest country in the world (1989).
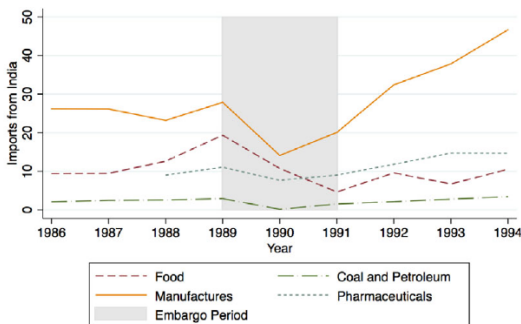- Thus: No savings or domestic production to smooth embargo impact.

Figure 12. Nepalese Imports by Sectors

Source: Chakravarty et al. (2021).

Background: Son preference

- Due to **patrilinear** social structure families prefer boys.
- Related with **missing women** concept: Sex-ratio disbalance in some countries due to social factors.
- Possible consequences: **Less investments** towards female (e.g no healthcare, shorter breastfeeding etc)
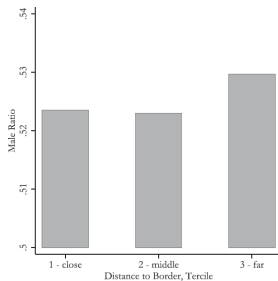
Figure 13. Share of male births before 1989 by tercile of distance to Indian border.

Source: Chakravarty et al. (2021).

Empirical Strategy

Main Specification:

$$H_i = \beta_0 + \beta_1 D_i + \gamma_i m(t) * D + \delta_i m(t) + \eta_i,$$

- H_i Health or human capital outcome of interest
- D_i born during the trade embargo
- $m(t)$ Polynomial in t

- β_1 identifies the parameter of interest for those being *affected by the embargo*.

Assumptions:

- Households **cannot manipulate** inutero exposure to the embargo.
- No other **concurrent shocks** occurring around March 1989.

Main Results

Table 3. Main Results.

	Live Births		Infant Death		Misscariages	
	1	2	3	4	5	6
Treated:						
All	−0.156	−0.0183			0.004	0.014
	(0.049)**	(0.052)***			(0.004)	(0.011)
Observations:					8.027	53.052
Male	−0.123	−0.133	0.026	0.03		
	(0.100)	(0.089)	(0.018)	(0.015)**		
Observations:			5.030	7.334		
Female	−0.193	−0.235	−0.003	−0.001		
	(0.024)***	(0.041)***	(0.018)	(0.015)		
Obseravations:	4.581	6.782				
Bandwidth	6	9	12	18	6	9

Source: Chakravarty et al. (2021).

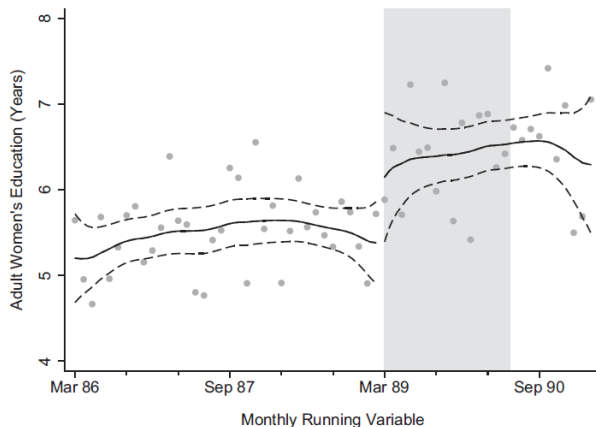# Long-term Results: Education

Figure 14. Long-run years of schooling: Women.

The graph shows average years of completed schooling by month of birth, and local linear regression plots with a triangular kernel. Source: Chakravarty et al. (2021).

Long-term Results: Education

Table 4. Main Results: Education (Female)

	Years of Schooling		Any Schooling	
	1	2	3	4
Optimal BW				
Treated	0.702	0.935	0.081	0.120
	(0.227***)	(0.325***)	(0.031***)	(0.047**)
Observations:	5.608	2.857	3.254	1.539
Bandwidth:	30	15	17	8
Other BW				
	0.876	0.879	0.132	0.107
	(0.541)	(0.426**)	(0.056**)	(0.044**)
Observations:	1.128	17.53	1.128	1.753
Bandwidth:	6	9	6	9

Source: Chakravarty et al. (2021).

Why those counter-intuitive findings?

- **Positive selection:**
  - Only the healthier girls survived.
  - Son preference in Nepal. Female newborn in gender discriminatory households more vulnerable that boys.
- (**Surviving**) women in remote (**poorer**) districts are 1.6-3.7 cm taller that the rest.
  - Higher health endowment at birth.
  - Indicator of households that invest more on them (no son preference).
- Households without any live birth (poorer) report more miscarriages.
- **Underreporting** of infant deaths and miscarriages.
- In high mortality contexts mortality selection can **offset** the (average) scarring effects of a shock.

Summary and Conclusions

Summary and Conclusions

- Both the epidemiological and economic literature suggest conditions early in life have long-lasting effects on **health** and **SES outcomes**.
- The **fetal origins hypothesis** postulates that **fetal nutrient intake** is main mechanism...
- ...affecting the **physiological development** of the fetus and triggering later responses (e.g. CVD, diabetes).
- How to claim that the effect of adverse in utero conditions on later outcome is **causal**? Common empirical strategies:
  - Exploiting **external shocks** (drought; epidemics; **war**) or policies (embargo).
- Early literature largely **atheoretical**: economic mechanisms creating (dis-)advantage not captured.
- Molina (2021) analyses if and how the **labour market** and **human capital investments** mediate an initial shock.
- Chakravarty et al. (2021) Emphasise the importance of **selective survival**.

Literature I

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