Birth Weight and Cognitive Development during Childhood: Evidence from India

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Abstract

Health at birth is an important indicator of human capital development over the life course. This paper uses longitudinal data from the Young Lives survey and employs instrumental variable regression models to estimate the effect of birth weight on cognitive development during childhood in India. We find that a 10 percent increase in birth weight increases cognitive test score by 8.1 percent or 0.11 standard deviations at ages 5-8 years. Low birth weight infants experienced a lower test score compared with normal birth weight infants. The positive effect of birth weight on a cognitive test score is larger for boys, children from rural or poor households, and those with less-educated mothers. Our findings suggest that health policies designed to improve birth weight could improve human capital in resource-poor settings.

Introduction

- **836** million people still live in extreme poverty (less than $1.25 per day).
- Low human capital accumulation such as – Education & Health are also causes of poverty and low economic development.
- Only 42.5% of grade III children were able to read grade I text in 2016.
- Low human capital can be due to "poor health at birth" or "**fetal origins hypothesis**" or **Barker's hypothesis**.
- **18%** of Indian infants born during 2010-2015 were low birth weight (LBW).
- LBW results in worse postnatal outcomes, educational outcomes, labor outcomes, and childhood and adult health outcomes.

Missing link between LBW and adult outcomes - Adult outcomes manifest through development in mid-childhood years (5-8 years) Adult outcomes take many years to manifest.

Research Questions - What is the impact of poor neonatal health (birth weight) on human capital accumulation in India in mid-childhood years?

❖ And does this relationship vary by socioeconomic conditions?

❖ Whether early neonatal health and parents inputs are complements are substitutes?

Fetal Origins Hypothesis - The origin of later-life health problems originates during in-utero or fetal stage.

Conceptual Framework -

$$Y_t = f(K_t, L_t, HK_t)$$

where, Y is output/poverty, K is physical capital, L is labor, and HK is "human capital".

$$HK_t = f(Education_t, Health_t)$$

$$H_t \text{ or } E_t = (H_{t-1}, H_{t-2}, H_{t-3} \ldots\ldots\ldots H_0, H_{-1})$$

where H_0 is health at the time of birth such as " birth weight or birth size"

$$Y_t = f(K_t, L_t, (H_{t-1}, H_{t-2}, H_{t-3} \ldots\ldots\ldots H_0, H_{-1}))$$

Methods and Materials

Data – *The Young Lives Survey (YL)*: A longitudinal study on childhood poverty, following 12,000 children in low-income countries: Ethiopia, India (Andhra Pradesh), Peru, and Vietnam since 2002; four rounds of 2002, 2007, 2009-10 & 2015 completed over 15 years.

Indian sample: one state, six districts, 20 sites.

Analytical sample: 2,000 one-year old (younger cohort).

Dependent variables: Peabody picture vocabulary test (PPVT score), log(PPVT score), PPVT z-score

Independent variables: BW, log(BW)

Confounding variables: Household caste, religion, birth order, age in months, father's education, mother's education, gender, age, education, poverty indicator, rural, breastfeeding.

Empirical Specification –

$$Y_{i,j,s} = \alpha + \beta_1 birthweight_{i,j,s} + \beta_2 X_{i,j,s} + \theta_s + \varepsilon_{i,j,s}$$

β_1, is biased estimate of BW effect due to unobserved genetic or environmental factors.

Solutions- Twins or Siblings fixed effect models; Natural shocks; Instrumental variable (public health budget, number of doctors, genetic variable (nucleotide polymorphisms).

Instrumental variable method:

First stage - $BW_{i,j,s} = \beta_0 + \beta_1 Z_{i,j,s} + \beta_2 X_{i,j,s} + \theta_s + \varepsilon_{i,j,s}$

Second stage - $Y_{i,j,s} = \eta_0 + \eta_1 BW_{i,j,s} + \eta_2 X_{i,j,s} + \theta_s + \varepsilon_{i,j,s}$

where

i indexes children, *j* indexes households, and *s* indexes sites

$Y_{i,j,s}$ is the "PPVT scores"

X is child and HH specific covariates (age, gender, birth order)

θ_s: site fixed effects

Standard errors are clustered at the child level.

Instruments – Mother's height and probability of pre-term birth: both instruments are likely to affect the intrauterine environment of mothers and fetus growth and in turn birth outcomes.

-If PTB independently affects cognition through brain development, then bias downward.

Results

Table 1: Summary statistics, N=1611

	Mean	S.D.			
PPVT score (2006)	27.44	21.12	Hindu	86%	-
PPVT score (2009)	58.48	30.45	Rich	33%	-
PPVT score (Pooled)	43.17	30.51	SCST	33%	-
Low birth weight	17%	-	Mother is primary schooled	38%	-
Birth weight (grams)	2763.65	547.34	Father is primary schooled	55%	-
Age of the child (months)	95.41	3.83	Exclusive breastfeeding	33%	-
Female	46%	-	Birth order	2.03	1.17
Rural	74%	-	Sentinals (#)	20	

Table 2: First stage results- correlation between the instruments and the endogenous variable

	Instrument: Mother's height	Instrument: Preterm birth	Instruments: Mother's height + Preterm birth
Mother's height	0.002** (0.0008)		0.002** (0.0009)
Preterm birth		-0.123*** (0.029)	-0.122*** (0.029)
Weak identification test			
Kleibergen-Paap Wald rk F statistic	5.71	17.69	12.75
Cragg-Donald Wald F statistic	7.52	61.86	32.98
Tests of overidentifying restrictions			
Sargan test p-value			0.859
Basmann p-value			0.861
p-value for endogeneity test			0.010

Notes: Robust standard errors, clustered at the community level, are in parentheses. Controls: Gender, birth order, and age of the child, household caste, father and mother's education, religion, household wealth, rural residence, exclusive breastfeeding, cluster dummies, and inverse mills term. *p< 0.10, **p<0.05, ***p<0.01

Table 3: 2SLS effect of birth weight on Cognitive outcome

	Instruments: Mother's height + Preterm birth	
	PPVT score (log)	PPVT z-score
Birth weight (log)	0.806** (0.393)	1.09** (0.522)
Cluster fixed effects	Yes	Yes
Inverse mills ratio	Yes	Yes
R-squared	0.47	0.41
Observations	1521	1521

Notes: Robust standard errors, clustered at the community level, are in parentheses. Controls: Gender, birth order, and age of the child, household caste, father and mother's education, religion, household wealth, rural residence, and exclusive breastfeeding. *p< 0.10, **p<0.05, ***p<0.01

Table 4: 2SLS effect of low birth weight (LBW) on Cognitive outcome

	Instruments: Mother's height + Preterm birth	
	PPVT score (log)	PPVT z-score
Low birth weight (dummy)	-0.659* (0.398)	-0.906* (0.502)
Cluster fixed effects	Yes	Yes
Inverse mills ratio	Yes	Yes
R-squared	0.42	0.38
Observations	1521	1521

Notes: Robust standard errors, clustered at the community level, are in parentheses. Controls: Gender, birth order, and age of the child, household caste, father and mother's education, religion, household wealth, rural residence, and exclusive breastfeeding. *p< 0.10, **p<0.05, ***p<0.01

Discussion of the magnitudes- Effect size: Birth weight effect ranges between 0.03-0.12 SD; Large scale education interventions in developing countries (Banerjee et al., 2007; Duflo and Hanna 2005; Muralidharanand Sundaraman 2009): Eect size range was 0.17-0.47 SD.

Table 7: Heterogeneity in effects: 2SLS effects of log(BW) birth on the test scores by child, mother, and household characteristics

	PPVT score(log)	PPVT z-score	F-stat	N
Urban	0.933	0.744	15.24	625
Rural	0.622**	1.149***	8.29	896
Boys	0.712*	1.083*	7.72	809
Girls	1.344*	1.617	5.99	712
Mother is primary schooled	0.427	0.328	7.95	877
Mother is not primary schooled	1.157**	1.90**	8.11	644
SCST	1.051	1.676	0.33	339
Other caste	0.576	0.857	17.84	1182
Poor	0.812*	1.161**	4.22	754
Rich	0.848	1.067	13.74	767

Notes: Robust standard errors, clustered at the community level, are in parentheses. Controls: Gender, birth order, and age of the child, household caste, father and mother's education, religion, household wealth, rural residence, probability of exclusive breastfeeding, inverse mills ratio, and cluster dummies. *p< 0.10, **p<0.05, ***p<0.01

Limitation

- Unable to use twin fixed effect for comparison
- YL representativeness
- Measurement error in birth weight and PPVT score
- Can't control for gestational weeks
- Unable to link birth weight and test score to labor market outcomes
- Evidence on parental investment is lacking (educational expenditure, postnatal investment (immunization))

Conclusions

❑ First causal study on BW effects in India

❑ Birth weight is strongly associated with test scores of children and has positive impacts on PPVT score

❑ Main findings are robust to inclusion of several confounding variables; evidence of heterogeneity in the effects of birth weight on test scores

❑ Nature Vs Nurture: nurture can remediate child's initial health disadvantage

Policy implications

❖ Food and nutritional supplementation program for the pregnant women could turn be an e effective strategy to improve human capital

Health at birth does matter for mid-childhood outcomes

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