Birth Weight Effects on Children's Development: Evidence from Twins Data

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Motivation

- **Low birth weight (LBW) is strongly correlated with many childhood and adulthood diseases**
- **Existing studies typically use cross-sectional study designs and are unable to control for maternal, environmental, and genetic factors correlated with LBW and outcomes**
- **Twins studies allow matching on maternal, environmental, and sometimes genetic factors**

Twins Literature

- Features
  - Use variation in birth weight within twin pairs
    - Fraternal twins are matched on maternal and environmental factors
    - Identical twins are additionally matched on genetic factors
  - Twin difference in birth weight reflect differences in fetal growth, not prematurity
- Findings
  - Typically examine the effect of birth weight on infant mortality and diseases in adulthood (Almond, Chay and Lee, 2004; Conley, Strully & Bennett, 2003; Hubbinette et al 2001; Iliadou et al, 2004; Behrman & Rosenzweig 2004)
  - Most studies find that within-twin estimates are smaller than between-twin estimates
- Limitations
  - Relatively few studies with typically small samples or samples outside US
  - No studies examining impact on early-life developmental outcomes

Our Research Questions

- Estimate the effect of VLBW (<1500g) and MLBW (1500-2499g) on children's developmental outcomes during the first two years of life using data from the US:
  - Mental Development
  - Motor Development
  - Growth (weight-for-age, length-for-age, weight-for-length)
- Compare within-twins and naïve estimates to assess the role of maternal, environmental and genetic factors in determining LBW and developmental outcomes

Data

- ECLS-B 9-month and 2-year data
- Oversampled LBW babies and multiple births
- Rich data on:
  - Birth weight (birth certificate)
  - Twin status and type
  - Mental and motor development scores (assessment)
  - Growth (measurement)
  - Sociodemographics, gestation, congenital anomalies, maternal health, prenatal care, pregnancy/labor complications
- Sample size
  - 7,300 singleton births
  - 600 fraternal twin pairs
  - 100 identical twin pairs

Empirical Model

$$h_{ij} = \alpha + \beta bw_{ij} + \gamma X_i + m_i + c_j + \varepsilon_{ij}$$

h_{ij} - developmental outcome for child j of mother i
bw_{ij} – birth weight
X_i – observable child, mother, family variables
m_i - mother-specific unobserved factors
c_j - child-specific unobserved factors
ε_{ij} - error term

Estimation

(1) Ordinary Least Squares (OLS)

$$h_{ij} = \beta_{ols} bw_{ij} + \gamma X_i + \upsilon_{ij}$$

where, $\upsilon_{ij} = m_i + c_j + \varepsilon_{ij}$

(2) Within-Twins (Twin Fixed Effects)

Fraternal Twins

$$h_{i1} - h_{i2} = \beta_{FT}(bw_{i1} - bw_{i2}) + (c_1 - c_2 + \varepsilon_{i1} - \varepsilon_{i2})$$

Identical Twins

$$h_{i1} - h_{i2} = \beta_{IT}(bw_{i1} - bw_{i2}) + (\varepsilon_{i1} - \varepsilon_{i2})$$

$$\beta_{IT} = \beta$$

Estimation

- **Model 1:** OLS on full sample (singletons and twins); n=8,650
- **Model 2:** OLS on twins sample; n=1,350
- **Model 3:** Within-twins regression on twins sample; n=1,350
- **Model 4:** Within-twins regression on fraternal twin sample; n=1,150
- **Model 5:** Within-twins regression on identical twin sample; n=200

Outcomes

- Mental and Motor Development Scores
  - Bayley Short Form – Research Edition
  - 31 item mental scale and 35 item motor scale
  - Scores computed based on IRT, which we later transform into z-scores
- Growth
  - Weight and length (height for children 2 and older) measured twice at each data collection by assessor
  - Use CDC growth charts to compute z-scores for:
    - weight-for-age (9-month and 2-year data)
    - weight-for-length (9-month data)
    - weight-for-stature (2-year data)
    - length-for-age (9-month data)

Descriptive Statistics

	Singleton births	All Twins	Fraternal twins	Identical twins
Birth weight				
Very low birth weight	0.098	0.14	0.143	0.125
Moderately Low birth weight	0.104	0.45	0.445	0.472
Child-level characteristics				
Female	0.486	0.51	0.502	0.551
Non-Hispanic Black	0.16	0.159	0.161	0.148
Hispanic	0.212	0.156	0.143	0.222
Other race/ethnicity	0.228	0.068	0.067	0.074
Gestation in weeks	37.812	35.308	35.289	35.407
Presence of congenital anomalies	0.117	0.205	0.209	0.185
Pregnancy characteristics				
Gestation in weeks at pregnancy recognition	5.588	5.222	5.134	5.685
Smoked in last trimester of pregnancy	0.117	0.107	0.098	0.157
Drank alcohol in last trimester of pregnancy	0.029	0.025	0.03	0

Descriptive Statistics (contd)

	Singleton births	All Twins	Fraternal twins	Identical twins
Maternal characteristics				
Maternal age at birth:				
Less than 20 years	0.122	0.061	0.06	0.065
Between 20 and 24.99 years	0.253	0.182	0.173	0.231
Between 25 and 29.99 years	0.244	0.262	0.258	0.282
Between 30 and 34.99 years	0.232	0.291	0.297	0.264
Maternal education at 9-months:				
High school diploma or equivalent	0.213	0.188	0.19	0.176
Some college or voc/tech program	0.263	0.277	0.282	0.255
Bachelors degree or higher	0.26	0.342	0.357	0.264
Income:				
Between $20001 and $40000	0.299	0.266	0.251	0.343
Between $40001 and $75000	0.092	0.076	0.08	0.056
Between $75001 and $100000	0.094	0.113	0.121	0.074
$100001 or higher	0.105	0.158	0.168	0.102
Married at birth	0.658	0.734	0.754	0.625

Results: Mental Development

	9-months	2-years
Model 1: Full sample		
VLBW	-0.941**	-0.668**
MLBW	-0.357**	-0.266**
Model 2: Twins sample		
VLBW	-0.696**	-0.607**
MLBW	-0.259**	-0.072
Model 3: Within Twins		
VLBW	-0.320*	-0.391**
MLBW	-0.185**	-0.156*
Model 4: Within Fraternal Twins		
VLBW	-0.342*	-0.436**
MLBW	-0.176**	-0.190*
Model 5: Within Identical Twins		
VLBW	-0.2	-0.066
MLBW	-0.243+	0.094

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

- **OLS**
  - **Large effect of VLBW at 9 months**
  - **Effect of MLBW also significant but smaller**
  - **Estimates from twins sample are slightly smaller than full sample**
- **Within-twins estimates**
  - **Significantly smaller, yet statistically significant and sizeable**
  - **Estimates from identical twins are smallest and statistically insignificant**
  - **No evidence of catch-up by age 2**

Results: Motor Development

	9-months	2-years
Model 1: Full sample		
VLBW	-0.968**	-0.756**
MLBW	-0.361**	-0.284**
Model 2: Twins sample		
VLBW	-0.751**	-0.567**
MLBW	-0.210**	-0.063
Model 3: Within Twins		
VLBW	-0.391**	-0.229
MLBW	-0.093+	-0.013
Model 4: Within Fraternal Twins		
VLBW	-0.417**	-0.258
MLBW	-0.092	0.026
Model 5: Within Identical Twins		
VLBW	-0.239+	-0.147
MLBW	-0.099	-0.306+

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

- **OLS**
  - **Large effect of VLBW at 9 months that reduces at 2 years**
  - **Estimates from twins sample are smaller than full sample**
- **Within-twins estimates**
  - **Significantly smaller than OLS**
  - **Only VLBW matters**
  - **Effects at age 2 become smaller and statistically insignificant**

Results: Weight-for-Age

	9-months	2-years
Model 1: Full sample		
VLBW	-1.766**	-1.472**
MLBW	-0.800**	-0.729**
Model 2: Twins sample		
VLBW	-1.950**	-1.508**
MLBW	-0.541**	-0.578**
Model 3: Within Twins		
VLBW	-1.487**	-1.244**
MLBW	-0.300**	-0.395**
Model 4: Within Fraternal Twins		
VLBW	-1.553**	-1.317**
MLBW	-0.272**	-0.390**
Model 5: Within Identical Twins		
VLBW	-1.159**	-0.814**
MLBW	-0.504**	-0.481*

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

- **OLS**
  - **Large effects of VLBW & MLBW at 9 months that reduce slightly at 2 years**
- **Within-twins estimates**
  - **Considerably smaller than OLS**
  - **Estimates from IT also sizeable and significant**
  - **No consistent evidence of catch-up by age 2**

Results: Weight-for-Length/Stature

	9-months	2-years
Model 1: Full sample		
VLBW	-0.571**	-0.999**
MLBW	-0.286**	-0.463**
Model 2: Twins sample		
VLBW	-0.730**	-1.031**
MLBW	-0.184	-0.435**
Model 3: Within Twins		
VLBW	-0.713**	-1.114**
MLBW	-0.108	-0.388**
Model 4: Within Fraternal Twins		
VLBW	-0.765*	-1.194**
MLBW	-0.073	-0.383*
Model 5: Within Identical Twins		
VLBW	-0.476	-0.653**
MLBW	-0.361+	-0.482*

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

- **OLS**
  - **Significant effect of VLBW & MLBW at 9 months**
  - **Effect becomes larger at age 2**
- **Within-twins estimates**
  - **Estimates similar to OLS estimates from twins sample**
  - **IT estimates are smaller than FT estimates**
  - **At 2 years, effects of VLBW and MLBW become larger**

Results: Length-for-Age

	9-months
Model 1: Full sample	
VLBW	-1.865**
MLBW	-0.829**
Model 2: Twins sample	
VLBW	-1.985**
MLBW	-0.630**
Model 3: Within Twins	
VLBW	-1.214**
MLBW	-0.351**
Model 4: Within Fraternal Twins	
VLBW	-1.246**
MLBW	-0.362**
Model 5: Within Identical Twins	
VLBW	-0.998**
MLBW	-0.263+

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

- **OLS**
  - **Large effect of VLBW and MLBW**
- **Within-twins estimates**
  - **Estimates smaller compared to OLS, yet statistically significant and sizeable**
  - **IT estimates are smaller than FT estimates**

Conclusions

- A significant part of the correlation between LBW and early life developmental outcomes is due to maternal, environmental, and genetic factors
  - $\beta_{ols} > \beta_{FT} > \beta_{IT}$
- Even when these factors are controlled for, there remains a sizeable detrimental effect of LBW on children's development in the first two years
- There is no consistent evidence of a catch-up occurring between LBW and NBW children during the first two years
  - Effect on weight-for-length becomes larger at 2 years
- Caveat: concerns about generalizeability of twins based estimates to singletons