

Born Too Small: The Effect of Low Birth Weight on Health and Development in Childhood

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Association between Birth Weight and Later Outcomes

Research shows a strong association between birth weight and a wide range of childhood and adult outcomes.

- Low birth weight (LBW) is associated with lower high school graduation and postsecondary enrollment, as well as lower IQ and academic achievement (Hack et al., 2002).
- LBW is associated with a higher risk for cardiovascular diseases and other chronic conditions later in life (Barker, 2004).

Causality or Confounding?

Two possible explanations:

1. **Possible causal pathway:** Underdeveloped organs, such as lungs and brains, during gestation (Saigal and Doyle, 2008).
 - Causal evidence informs the importance of interventions to reduce low birth weight.
2. **Alternative explanation:** Parental and environmental factors may influence both birth weight and later-life outcomes.
 - Correlational evidence guides the targeting of infant health interventions.

Literature of Birth Weight

Research using sibling- and twin-fixed effects models consistently finds a strong association between birth weight and outcomes in both childhood and adulthood.

1. **Short-term outcomes:** Almond et al. (2005) examine immediate postnatal outcomes, such as APGAR-score, hospital costs, and infant mortality, and find that the causal effects of low birth weight are substantially smaller than previously estimated.
2. **Long-term outcomes:** Numerous studies examine adult outcomes, including educational attainment, earnings, and adult health (Black et al., 2007; Behrman and Rosenzweig, 2004; Bharadwaj et al., 2018b; Royer, 2009), and find that higher birth weight has positive effects on long-term outcomes.

Missing Middle

- However, research tracing the full developmental pathway between birth and adulthood remains limited.
 - Academic achievement have been well-documented, see Bharadwaj et al. (2018a); Cesur and Kelly (2010); Figlio et al. (2014); Oreopoulos et al. (2008).
- Much less is known about how birth weight shapes health and development from birth through adolescence.
- Almond et al. (2018) called this *the missing middle*, the missing childhood between early childhood and adulthood.

Objective

This paper examines the relationship between birth weight and children's health and development throughout childhood, using unique Dutch administrative data.

Preventive Youth Health Care

- First study to link novel Preventive Youth Health Care (PYHC) data from four regions to administrative records.
- PYHC monitors children's health and development and provides free services to all children in the Netherlands.
- Children receive 12 check-ups before age four, and three additional check-ups thereafter.
- High participation (~95% take-up rate)

Outcomes

Outcomes of the PYHC sample:

- Weight and height: underweight and overweight (WHO BMI-to-age)
- Speech and language development (Van Wiechenonderzoek)
- Psychosocial development (SDQ score)

Outcomes of the administrative sample:

- Educational outcomes in primary and secondary school, and young adulthood
- Hospital and mental health care costs
- Involvement of youth protection services

Samples

Birth records were linked to Preventive Youth Health Care (PYHC) and other administrative data

1. PYHC linkage (unbalanced)
 - Birth years: 2000-2017
 - Observation years: 2009-2018
 - Number of children: 119,298
2. Administrative data (universe)
 - Birth years: 2000-2020
 - Number of children: 3,105,103

Methods

- Estimate the causal impact of birth weight using **sibling and twin fixed-effects models**
 - Sibling-FE controls for maternal unobservable time-invariant determinants
 - Twin-FE also controls maternal unobservable time-varying determinants
- Controls included: child's sex and age, mother's age at birth, gestational age, parity
- Modeling approaches:
 1. Log-linear and level-linear regressions
 2. Regression with birth weight quantiles to account for nonlinearities

Overweight and Underweight in Childhood

- **Overweight:** BMI-for-age Z-score $> +1$ SD (WHO sex- and age-specific references (WHO, 2006, 2023))
- **Underweight:** BMI-for-age Z-score < -2 SD (WHO sex- and age-specific references)
- BMI (weight and height) is measured from birth to age 14 at each check-up.

Log-linear and Level-linear Regression

Age	Overweight		Underweight	
	Level (1)	Log (2)	Level (3)	Log (4)
4 Weeks	0.030*** (0.001)	0.969*** (0.046)	-0.004*** (0.000)	-0.164*** (0.016)
8 Weeks	0.0130*** (0.001)	0.421*** (0.039)	-0.005*** (0.001)	-0.253*** (0.020)
3 Months	0.010*** (0.001)	0.331*** (0.039)	-0.004*** (0.001)	-0.172*** (0.024)
4 Months	0.008*** (0.001)	0.236*** (0.035)	-0.004*** (0.001)	-0.179*** (0.022)
6 Months	0.009*** (0.001)	0.290*** (0.043)	-0.002*** (0.001)	-0.090*** (0.021)
7.5 Months	0.008*** (0.002)	0.266*** (0.072)	-0.003*** (0.001)	-0.096*** (0.034)
11 Months	0.013*** (0.001)	0.406*** (0.047)	-0.002*** (0.000)	-0.068*** (0.013)
14 Months	0.017*** (0.002)	0.542*** (0.051)	-0.001*** (0.000)	-0.031*** (0.008)

Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$

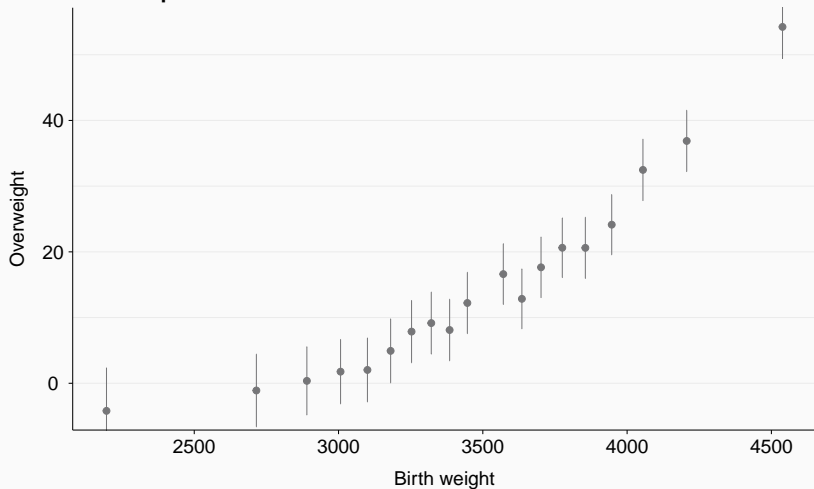
Log-linear and Level-linear Regression

Age	Overweight		Underweight	
	Level (1)	Log (2)	Level (3)	Log (4)
18 Months	0.017*** (0.003)	0.559*** (0.091)	0.000 (0.001)	-0.011 (0.017)
Age 2	0.018*** (0.001)	0.585*** (0.038)	-0.001*** (0.000)	-0.043*** (0.007)
Age 3	0.016*** (0.001)	0.493*** (0.038)	-0.002*** (0.000)	-0.052*** (0.007)
Age 3 and 9 Months	0.016*** (0.001)	0.502*** (0.037)	-0.001*** (0.000)	-0.036*** (0.007)
Group 2 (Age 6)	0.010*** (0.002)	0.349*** (0.050)	-0.001*** (0.000)	-0.050*** (0.014)
Group 7 (Age 11)	0.005*** (0.002)	0.176*** (0.053)	-0.003*** (0.001)	-0.124*** (0.021)
Class 2 (Age 14)	0.002 (0.002)	0.045 (0.078)	-0.002* (0.001)	-0.078** (0.040)

Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$

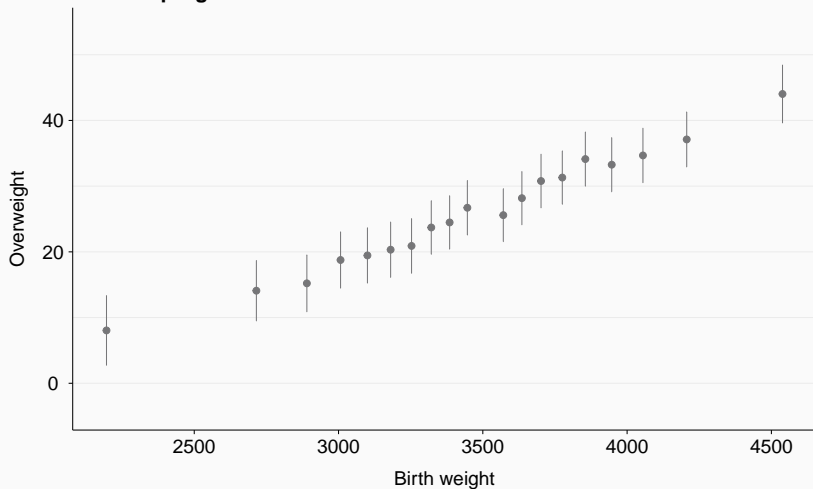
Nonlinearities in Birth Weight

Association between Birth Weight and Being Overweight at Check-up 4 Weeks



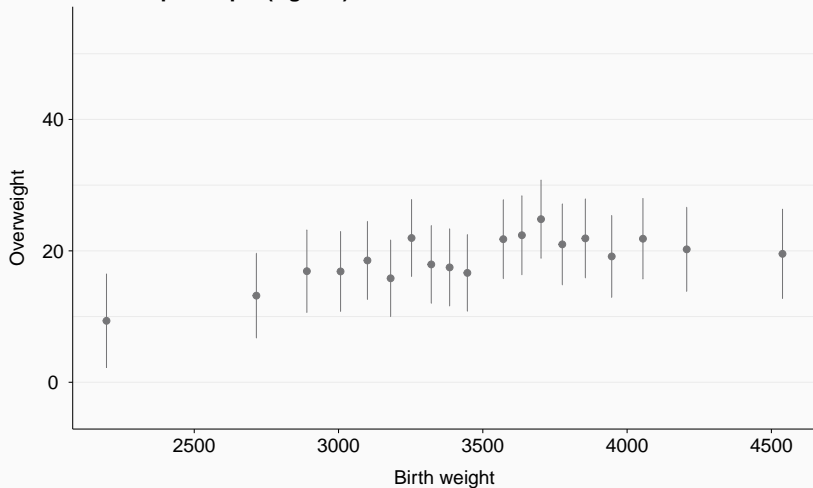
Nonlinearities in Birth Weight

Association between Birth Weight and Being Overweight at Check-up Age 2



Nonlinearities in Birth Weight

Association between Birth Weight and Being Overweight at Check-up Group 7 (Age 11)



Educational Outcomes

Age	Description
Group 8 in primary school	1. Test Score Mathematics Target Level
	2. Test Score Reading Comprehension Target Level
	3. Test Score Grammar and Writing Target Level
	4. VMBO-GL Test Score Track
	5. HAVO Test Score Track
	6. VWO Test Score Track
Age 16 in secondary school	7. VMBO-GL Track
	8. HAVO Track
	9. VWO Track
Age 21	10. Obtained High School Degree
	11. Higher Professional education (HBO) Enrollment
	12. University Enrollment

Log-linear and Level-linear Regression

Outcome	Siblings		Twins	
	Level (1)	Log (2)	Level (3)	Log (4)
A. Group 8 in Primary School				
Math Target Level	0.004*** (0.000)	0.150*** (0.000)	0.005*** (0.001)	0.108*** (0.027)
Reading Target Level	0.002*** (0.000)	0.063*** (0.000)	0.002** (0.001)	0.046* (0.025)
Language Target Level	0.002*** (0.000)	0.057*** (0.000)	0.002 (0.001)	0.051* (0.028)
VMBO-GL Test Score Track	0.003*** (0.000)	0.111*** (0.000)	0.004*** (0.001)	0.083*** (0.024)
HAVO Test Score Track	0.003*** (0.000)	0.124*** (0.000)	0.003** (0.001)	0.068*** (0.025)
VWO Test Score Track	0.002*** (0.000)	0.064*** (0.000)	0.002** (0.001)	0.041** (0.020)

Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$

Log-linear and Level-linear Regression

Outcome	Siblings		Twins	
	Level (1)	Log (2)	Level (3)	Log (4)
B. Age 16 in Secondary School				
VMBO-GL Track	0.003*** (0.000)	0.098*** (0.000)	0.002** (0.001)	0.047** (0.021)
HAVO Track	0.004*** (0.000)	0.130*** (0.000)	0.002** (0.001)	0.062** (0.026)
VWO Track	0.002*** (0.000)	0.077*** (0.000)	0.002 (0.001)	0.033 (0.022)
C. Age 21				
Obtained High School Degree	0.002*** (0.000)	0.077*** (0.000)	0.001 (0.001)	0.036 (0.026)
HBO Enrollment	0.004*** (0.000)	0.137*** (0.000)	0.004*** (0.001)	0.110*** (0.030)
University Enrollment	0.002*** (0.000)	0.087*** (0.000)	0.002** (0.001)	0.057** (0.024)

Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$

Overview of Results

Outcome	Finding
Weight	Birth weight is associated with overweight and underweight in primary school (fading by secondary)
Speech and Language Development	Mixed results at ages 2 and 3
Psychosocial development	No significant association between birth weight and SDQ scores from ages 3 to 14
Educational Outcomes	A strong positive relationship between birth weight and academic performance
Hospital costs	Birth weight is strongly associated with hospital costs at age 0, persisting to age 10 among siblings but not among twins

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