Can Intensive Early Childhood Intervention Programs Eliminate Income-Based Cognitive and Achievement Gaps?

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Research Topic

Question: how much could U.S. income-based cognitive and achievement gaps be closed by early childhood intervention programs? Targeted or universal?

Known: they work for kids from lower-income families => Targeted programs would **reduce** gaps.

Unknown:

By how much nationally?

Do they work among kids from higher-income families => Universal program impacts?
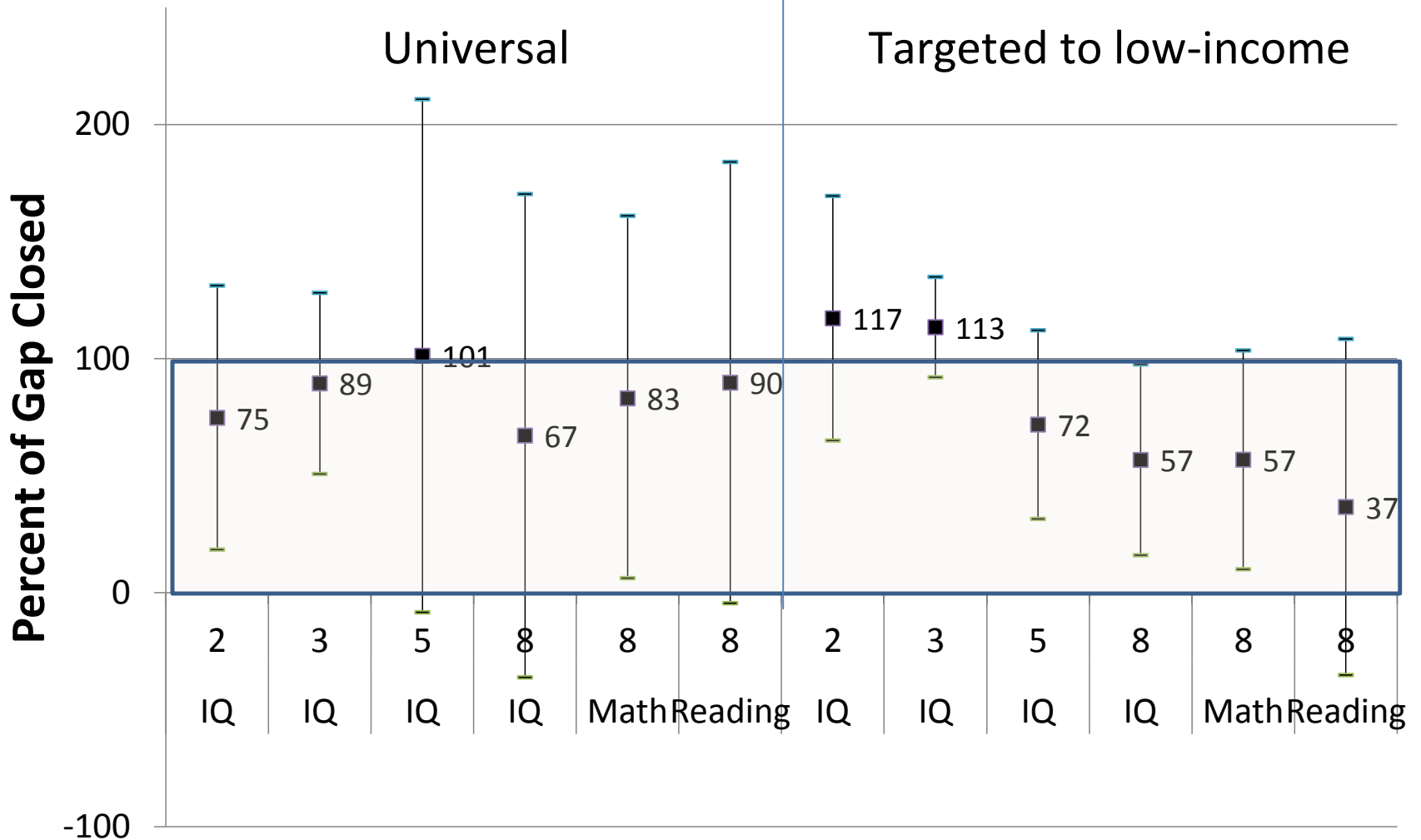
Research Approach

Use experiment that included kids from both lower-income and **higher-income** families, ran through age 3.

Weight this unrepresentative sample to match the ECLS-B national birth cohort on maternal demographics.

Estimate program impacts for each income group.

Estimate fraction of U.S. cognitive and achievement gaps that would be closed at ages 1, 2, 3, 5, and 8 years under universal and targeted intervention programs.

Percent of Cognitive and Achievement Gaps Closed by Universal and Targeted program, by Age of Child

Universal

Targeted to low-income

Percent of Gap Closed

200

100

0

-100

75   89   101   67   83   90   117   113   72   57   57   37

| 2 | 3 | 5 | 8 | 8 | 8 | 2 | 3 | 5 | 8 | 8 | 8 |
| IQ | IQ | IQ | IQ | Math | Reading | IQ | IQ | IQ | IQ | Math | Reading |

Measuring an income-based gap

Start with a nationally representative sample.

Measure family income at birth. Indicate child from lower-income family with L_i =1.

Measure outcome of interest: Y_i

Empirical model of gap

$$Y_i = \alpha_0 - \alpha_1 L_i + \varepsilon_i$$

	No program
Predicted outcome among higher-income (L=0)	α_0
Predicted among lower-income (L=1)	$\alpha_0 - \alpha_1$
Predicted Gap	α_1

Ideal gap-closing experiment

Start with a nationally representative sample.

Measure family income at birth. Indicate child from lower-income family with L_i =1.

Randomly assign individuals in each income group to treatment, indicated with T_i =1.

Measure outcomes of interest over time: Y_i

Empirical Model of Gap Closing

Income gap

$$Y_i = \alpha_0 - \alpha_1 L_i + \alpha_2 T_i + \alpha_3 T_i L_i + \varepsilon_i$$

Treatment effect among higher-income

How much bigger is treatment among lower-income than higher-income

	No program (T=0)
Predicted among higher-income (L=0)	α_0
Predicted among Lower-income (L=1)	α_0-α_1
Predicted Gap	α_1

Empirical Model of Gap Closing

Income gap

$$Y_i = \alpha_0 - \alpha_1 L_i + \alpha_2 T_i + \alpha_3 T_i L_i + \varepsilon_i$$

Treatment effect among higher-income

How much bigger is treatment among lower-income than higher-income

	No program (T=0)	Universal (T=1)
Predicted among higher-income (L=0)	α_0	$\alpha_0 + \alpha_2$
Predicted among Lower-income (L=1)	$\alpha_0 - \alpha_1$	$\alpha_0 - \alpha_1 + \alpha_2 + \alpha_3$
Predicted Gap	α_1	$\alpha_1 - \alpha_3$
Portion of gap closed (C_a)		α_3 / α_1

Empirical Model of Gap Closing

$$Y_i = \alpha_0 - \alpha_1 L_i + \alpha_2 T_i + \alpha_3 T_i L_i + \varepsilon_i$$

	No program (T=0)	Universal (T=1)	Targeted (T=L)
Predicted among higher-income (L=0)	α_0	$\alpha_0+\alpha_2$	α_0
Predicted among Lower-income (L=1)	$\alpha_0-\alpha_1$	$\alpha_0-\alpha_1+\alpha_2+\alpha_3$	$\alpha_0-\alpha_1+\alpha_2+\alpha_3$
Predicted Gap	α_1	$\alpha_1-\alpha_3$	$\alpha_1-\alpha_2-\alpha_3$
Portion of gap closed (C_a)		α_3/α_1	$(\alpha_2+\alpha_3)/\alpha_1$

Literature

There are large, growing gaps in academic achievement and IQ between kids of different income/SES (α_1).

(Duncan & Magnuson, 2011; Reardon , 2011)

Strong experimental evidence that high-quality early childhood environment can raise achievement, but only from samples selected to be low-income ($\alpha_2 + \alpha_3$).

(Karoly, 2001; Heckman, Grunewald & Reynolds, 2006; Bartik, 2011)

Evidence that impacts among higher-income samples (α_2) are small or even negative, but nonexperimental.

(Gormley et al, 2008; Bartik et al, 2011; Bernal & Keane, 2010)

The experimental treatment

The Infant Health & Development Program (IHDP) recruited a sample at birth and randomly assigned a treatment.
(Brooks-Gunn et al, 1994; McCarton et al, 1997; Gross et al, 1997)

   Age 0-1: weekly home visit from staff

   Age 1-3: child eligible for child development center (CDC)
        Free
        Full-day
        High-quality, Abecedarian curriculum
        Free transportation

CDC cost would be about $24K/year (updates Gross et al to 2006$).
Without transportation or children with disabilities, $15K/year.

The experimental sample

Rather than strictly income-based, IHDP program selected on a different criteria.

Ethnically and economically diverse but sample only included children born:

Low-birth weight (≤ 2.5 kg = 5.5 lbs)

Premature (≤ 37 wks)

In one of 8 research hospitals around country

Starting January 7, 1985 until fully enrolled

Experiment gives internal validity, but what about external?

Main concern: how well can the IHDP's sample represent the population of U.S. children?

Approach:

Use only high LBW subsample (2.0 - 2.5 kg).

Reweight to match ECLS-B on maternal education, race/ethinicity, and marital status.

Check how well average outcomes match.

Use HLBW. Exclude LLBW.

HLBW are closer to normal birth weight.
   (Klebanov et al, 1994a; Klebanov et al, 1994b)

LLBW suffer more biological compromise. Intervention effects here may not generalize.

IHDP includes 362 HLBW children. About a third in treatment and two-thirds in control.

IHDP HLBW sample

| Variable	N	Mean	SD
Age 1 IQ z-score	330	0.78	1.04
Age 2 IQ z-score	322	-0.04	1.36
Age 3 IQ z-score	328	-0.68	1.32
Age 5 IQ z-score	295	-0.43	1.17
Age 8 IQ z-score	311	-0.38	1.16
Age 8 reading achvmt.	308	0.02	1.36
Age 8 math achvmt.	312	-0.03	1.41
White/other	362	0.40	
African-American	362	0.48	
Hispanic	362	0.12	
Mother without any college	362	0.67	
Mother with any college	362	0.33	
Income/needs ratio at 12 months	325	1.86	1.88
Income/needs < 1.8 indicator	325	0.66	

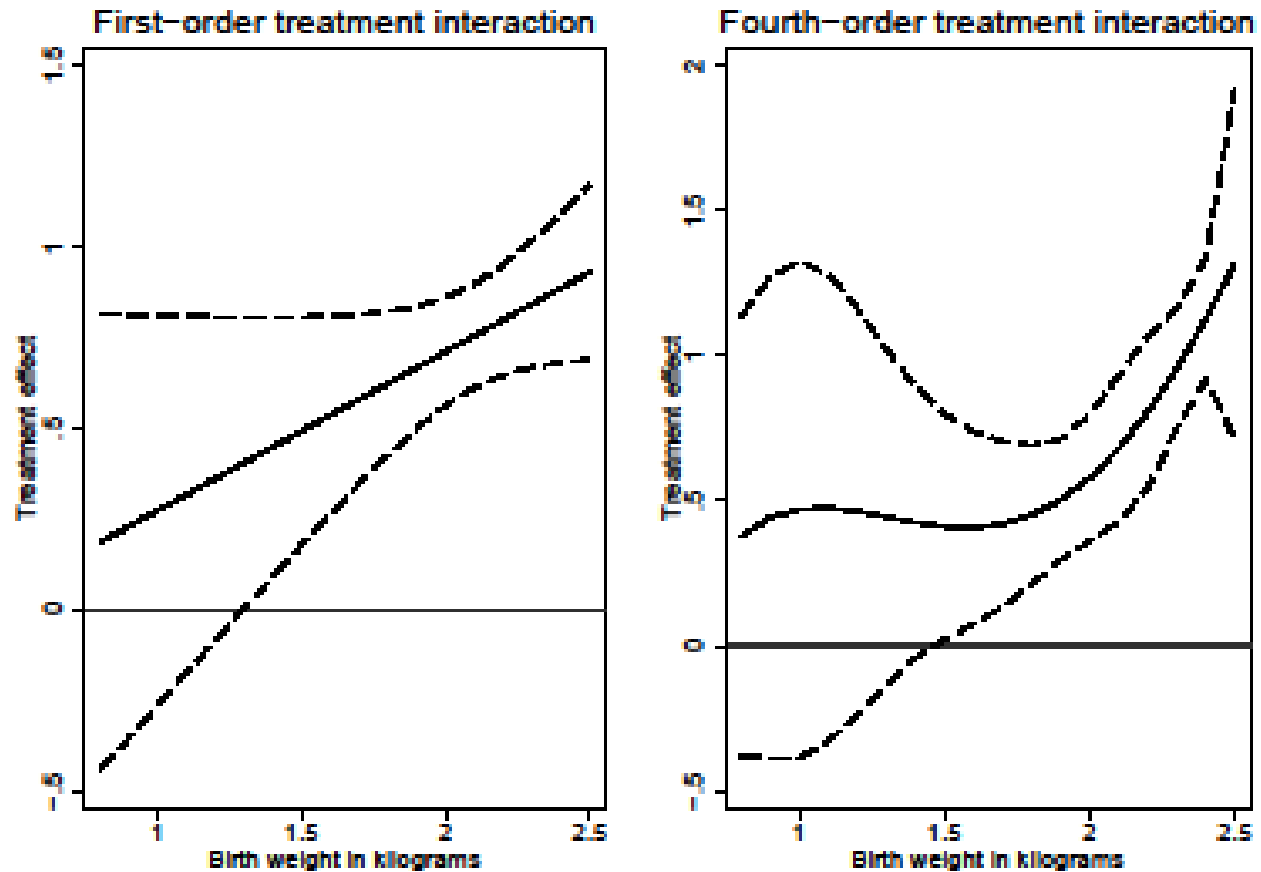# Concerned if treatment effects differ by birth weight?
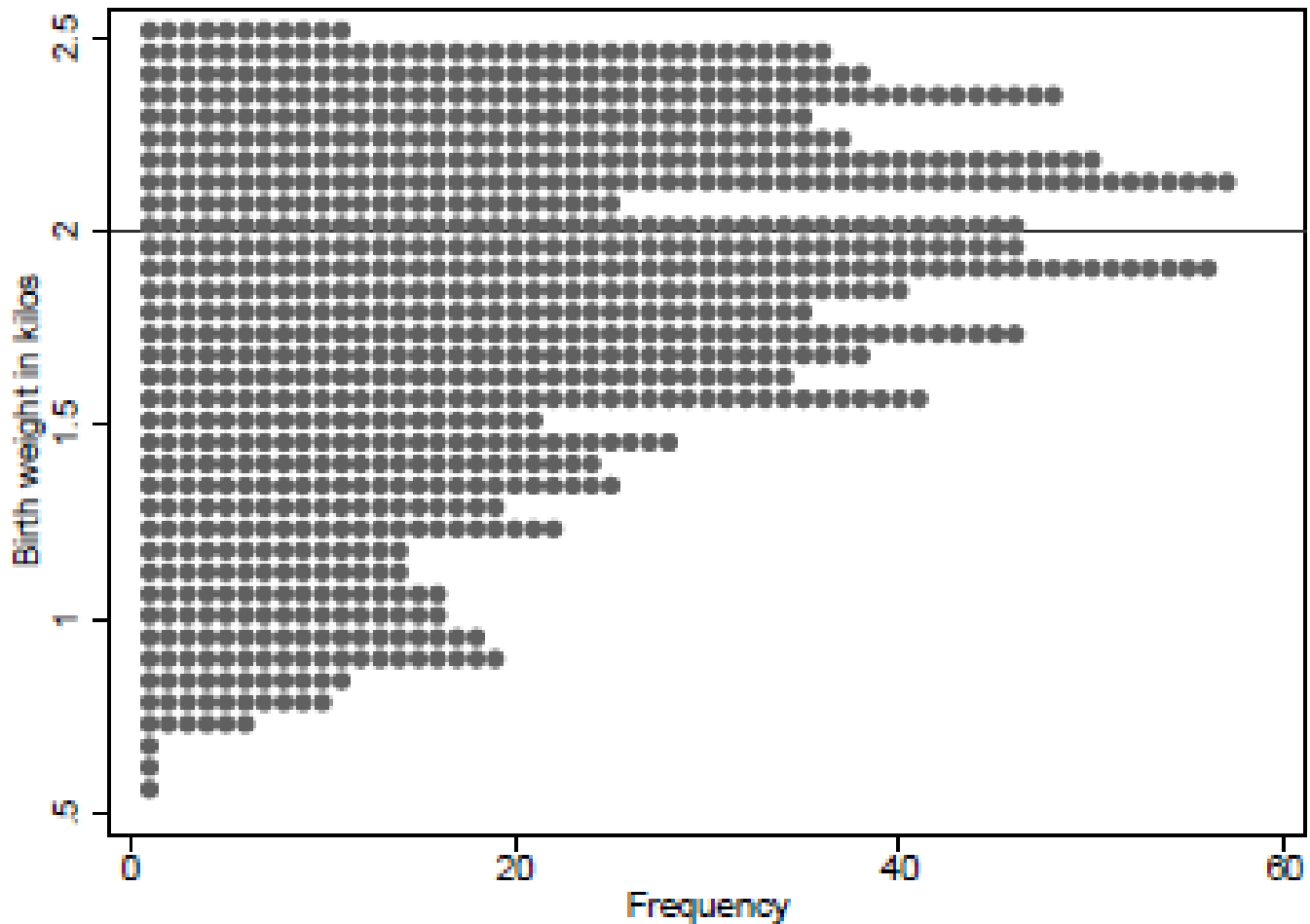
Treatment effects bigger for those closer to normal birth weight: age-1 IQ
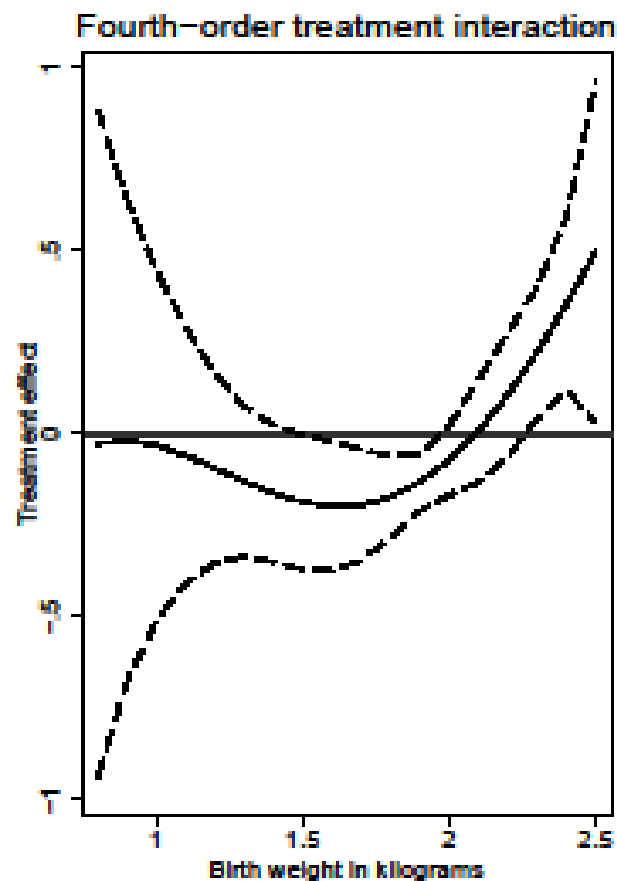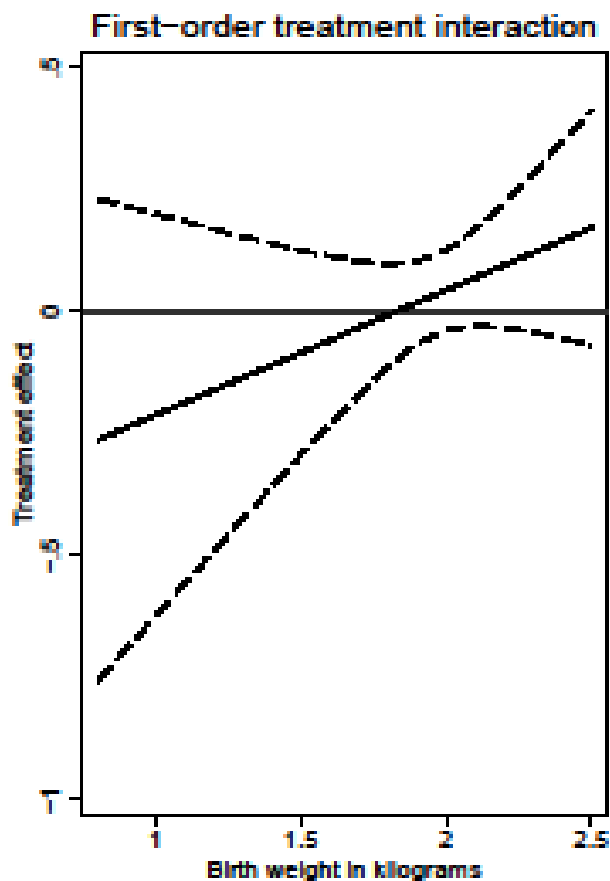
Same for age-2 IQ
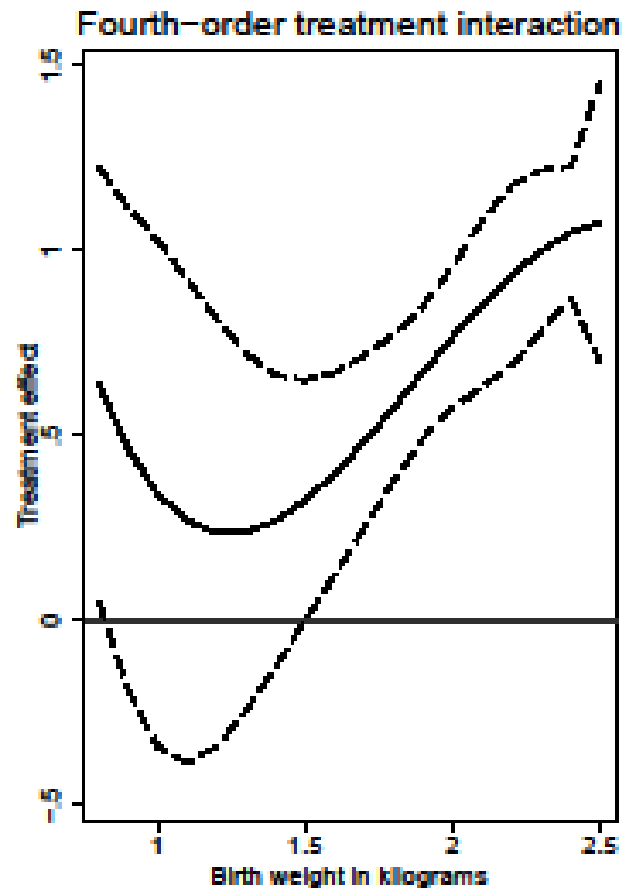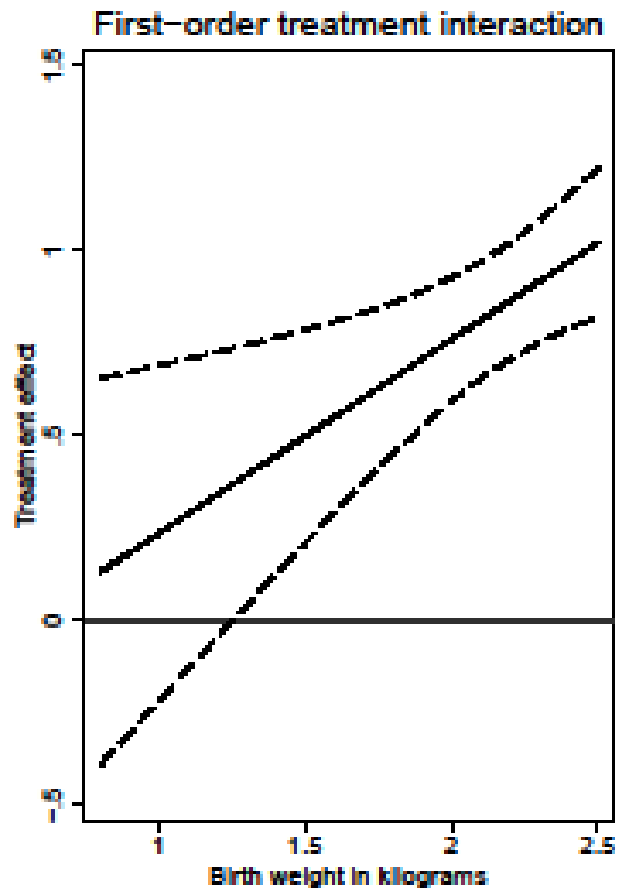
Same for age-3 IQ

Same for age-5 IQ
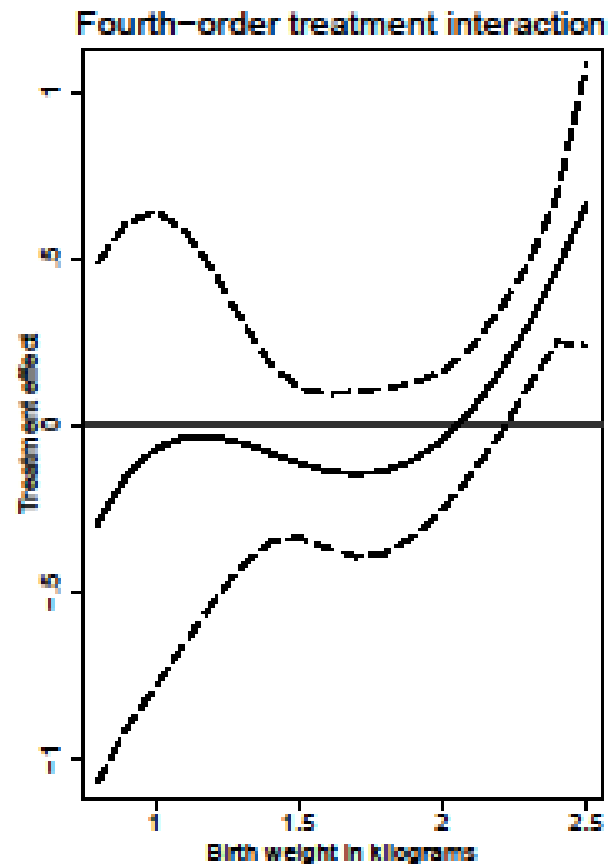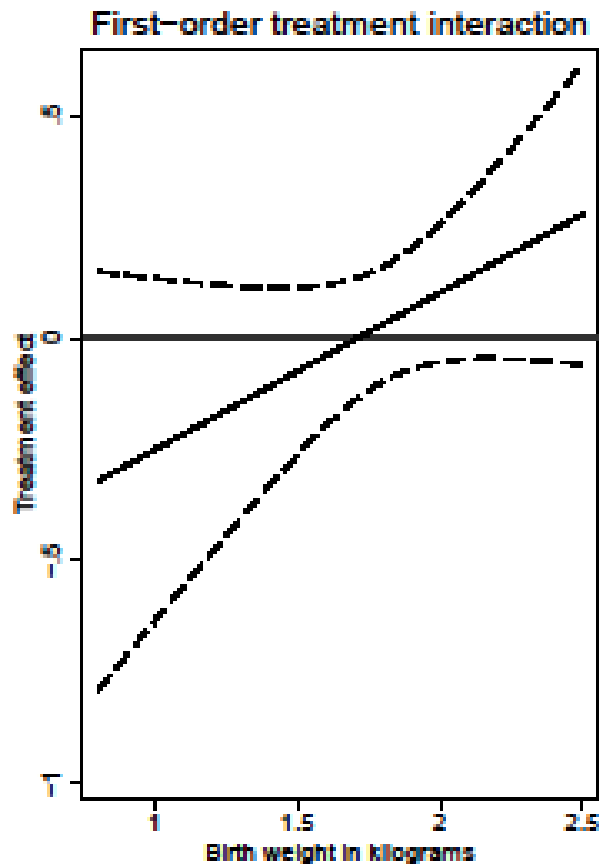
Same for age-8 IQ
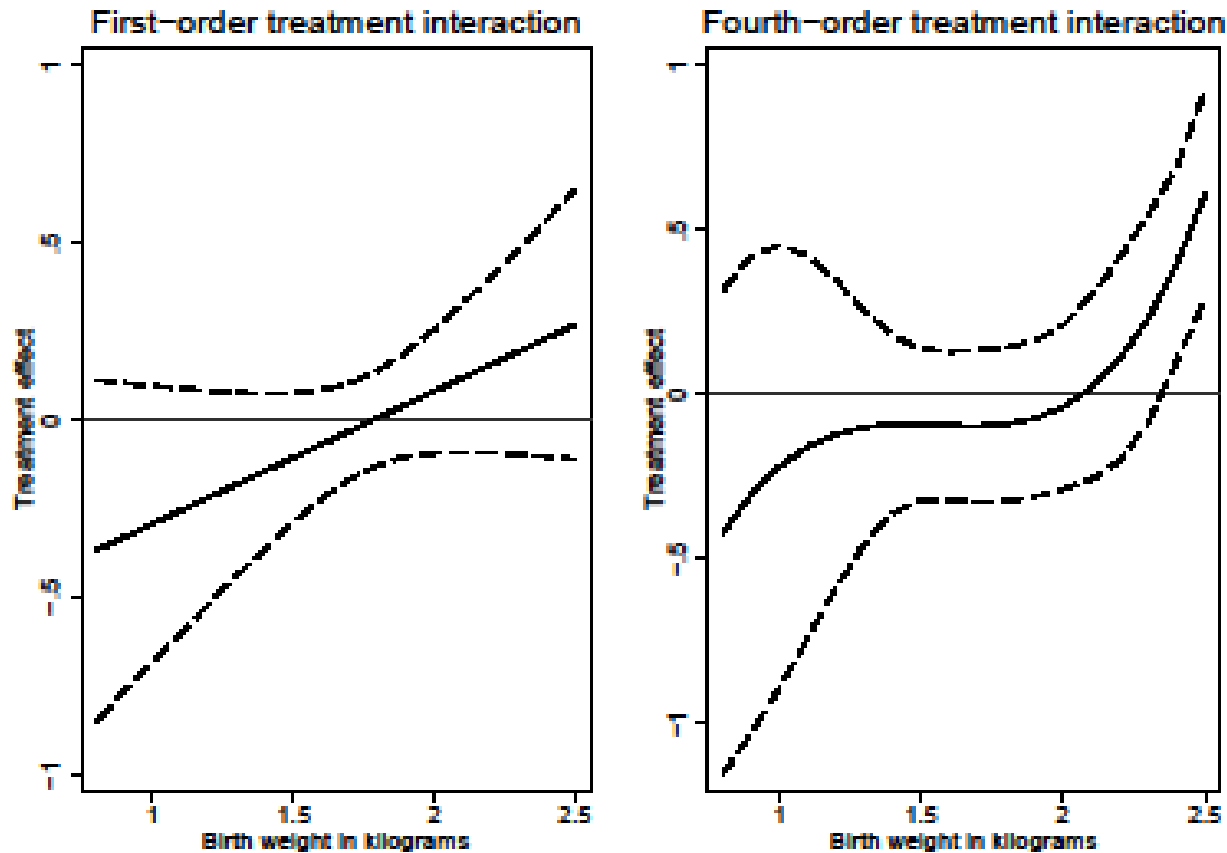
Same for age-8 reading achievement
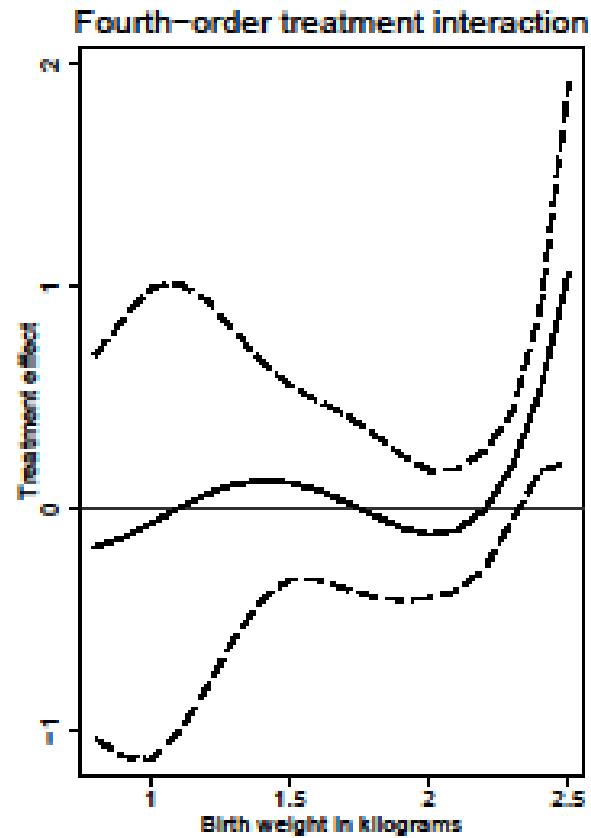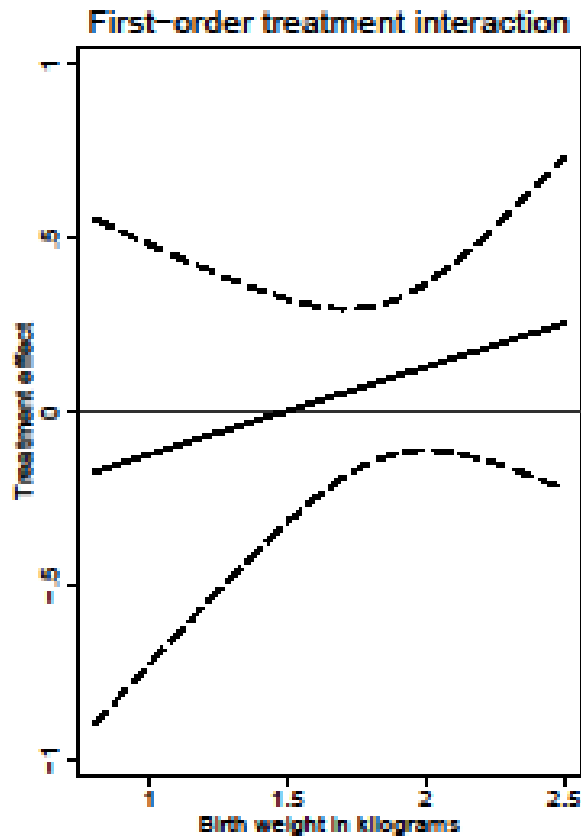
Same for age-8 math achievement

First-order treatment interaction

Fourth-order treatment interaction
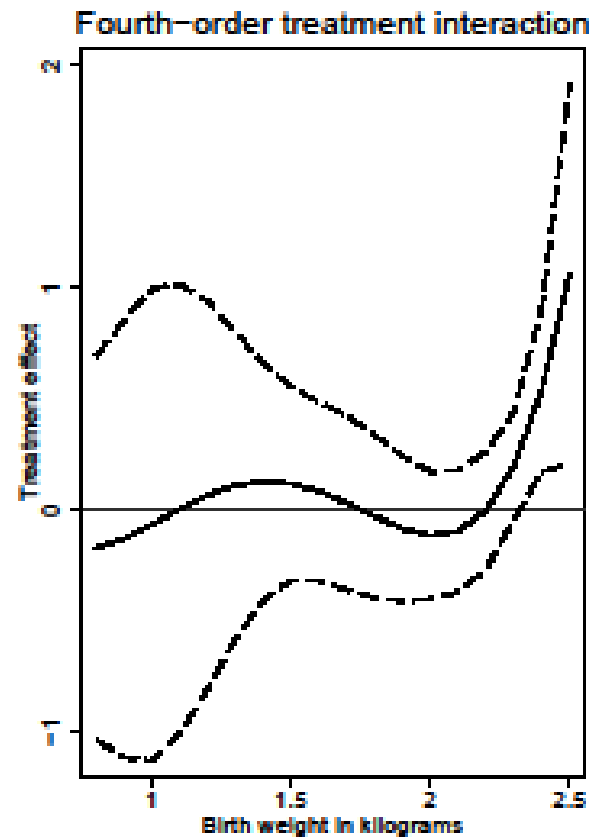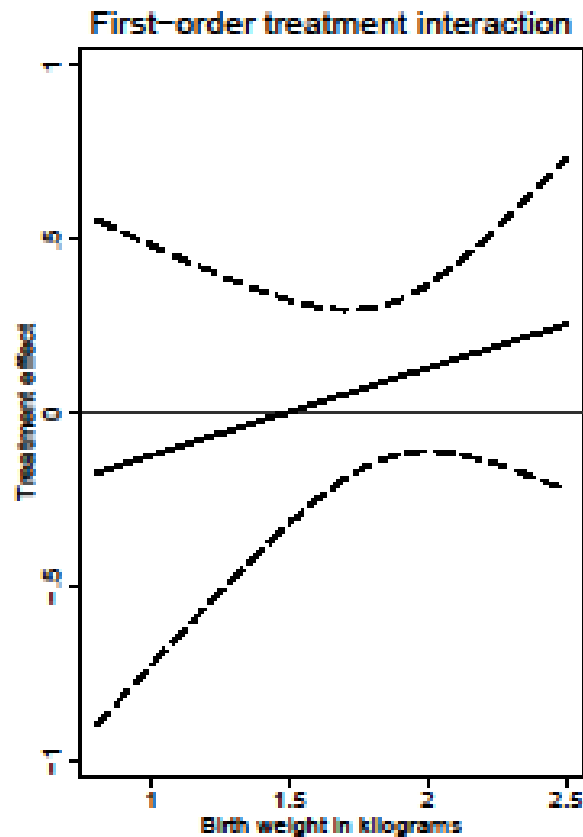
Re-weight HLBW to match ECLS-B

In each sample, find the proportion of cases with each combination of maternal:

- Lower-income (2): below 180% poverty or not
- Race/Ethnicity (3)
- Martial status (2)
- Education (2)

Weight each IHDP HLBW observation by the ratio of ECLS:IHDP proportions.

Measuring lower-income status (*L*)

Family income measured at 12 months for 325 of 362 in IHDP. Missing for 37.

Multiply impute missing *L* on the basis of pre-assignment characteristics:

maternal age, race, education, number of living children, and previous number of LBW, premature children at time of study child's birth; study child's weight, gestational age, neonatal health index, and parity order at birth; and study site indicators.

Number of replicates imputed low-income, of 10	0	1	2	3	4	5	6	7	8	9	10	Total
Frequency	0	1	0	0	2	2	3	6	3	11	9	37

IHDP HLBW Sample by Matched Maternal Demographics

Family income	Ethnicity	Maternal Marital Status & Education			
		Married		Unmarried	
		No college	Any college	No college	Any college
Low income	White/other	0.066	0.025	0.044	0.011
	African-Am.	0.052	0.030	0.251	0.033
	Hispanic	0.022	0.006	0.052	
Not low-inc.	White/other	0.036	0.160	0.014	0.008
	African-Am.	0.019	0.017	0.019	0.011
	Hispanic	0.006	0.008	0.006	
Income Missing	White/other	0.014	-	0.022	0.003
	African-Am.	0.006	0.003	0.033	0.006
	Hispanic	0.003	-	0.014	

ECLS:IHDP ratios

Family income	Ethnicity	Maternal Marital Status & Education			
		Married		Unmarried	
		No college	Any college	No college	Any college
Low income	White/other	0.92 (0.02)	2.14	1.17 (0.06)	1.99 (0.22)
	African-Am.	0.18 (0.00)	0.28 (0.01)	0.22 (0.00)	0.43 (0.02)
	Hispanic	2.48 (0.09)	3.32	1.21 (0.18)	
Not low-inc.	White/other	1.66 (0.08)	1.94	1.16 (0.16)	2.21 (0.32)
	African-Am.	0.25 (0.00)	0.96 (0.07)	0.25 (0.02)	0.81 (0.11)
	Hispanic	3.09 (0.39)	3.69	3.58 (0.88)	

Summary outcome statistics for the weighted IHDP

IHDP HLBW Sample:

Variable	N	Mean	SD
		All Unweighted	
Age 1 IQ z-score	330	0.78	1.04
Age 2 IQ z-score	322	-0.04	1.36
Age 3 IQ z-score	328	-0.68	1.32
Age 5 IQ z-score	295	-0.43	1.17
Age 8 IQ z-score	311	-0.38	1.16
Age 8 reading achvmt.	308	0.02	1.36
Age 8 math achvmt.	312	-0.03	1.41

Summary outcome statistics for the weighted IHDP

IHDP HLBW Sample:		All Unweighted		All ECLS-B weights	
Variable	N	Mean	SD	Mean	SD
Age 1 IQ z-score	330	0.78	1.04	0.88	1.01
Age 2 IQ z-score	322	-0.04	1.36	0.23	1.42
Age 3 IQ z-score	328	-0.68	1.32	-0.29	1.44
Age 5 IQ z-score	295	-0.43	1.17	0.03	1.18
Age 8 IQ z-score	311	-0.38	1.16	0.09	1.16
Age 8 reading achvmt.	308	0.02	1.36	0.42	1.36
Age 8 math achvmt.	312	-0.03	1.41	0.27	1.40

Summary outcome statistics
for the weighted IHDP

IHDP HLBW Sample:		All Unweighted		All ECLS-B weights		Control only ECLS-B weights	
Variable	N	Mean	SD	Mean	SD	Mean	SD
Age 1 IQ z-score	330	0.78	1.04	0.88	1.01	0.86	0.99
Age 2 IQ z-score	322	-0.04	1.36	0.23	1.42	-0.03	1.39
Age 3 IQ z-score	328	-0.68	1.32	-0.29	1.44	-0.60	1.42
Age 5 IQ z-score	295	-0.43	1.17	0.03	1.18	-0.03	1.09
Age 8 IQ z-score	311	-0.38	1.16	0.09	1.16	0.04	1.11
Age 8 reading achvmt.	308	0.02	1.36	0.42	1.36	0.46	1.35
Age 8 math achvmt.	312	-0.03	1.41	0.27	1.40	0.25	1.38

IQ effects larger for low-income

Outcome		A	B	C
Age 5 IQ (n=295)	Treatment	0.102 (0.116)	0.148 (0.166)	-0.264 (0.201)
	Low income		-0.509* (0.246)	-0.820*** (0.231)
	Treatment x (Low income)			0.861*** (0.201)
Age 8 IQ (n=311)	Treatment	0.156 (0.158)	0.224 (0.169)	-0.067 (0.323)
	Low income		-0.595** (0.185)	-0.806*** (0.196)
	Treatment x (Low income)			0.572 (0.361)

Coefficient (within site correlation corrected SE). Significance: *0.10 **0.05 ***0.01.
All models also condition on child gender, birth weight, gestational age at birth, neonatal health index and site indicators. IHDP HLBW sample with ECLS-B weights.

Percent of Cognitive and Achievement Gaps Closed by Universal and Targeted IHDP, by Age of Child

Universal   Targeted to low-income

Percent of Gap Closed

Age	2	3	5	8	8	8	2	3	5	8	8	8
Measure	IQ	IQ	IQ	IQ	Math	Reading	IQ	IQ	IQ	IQ	Math	Reading
Value	75	89	101	67	83	90	117	113	72	57	57	37
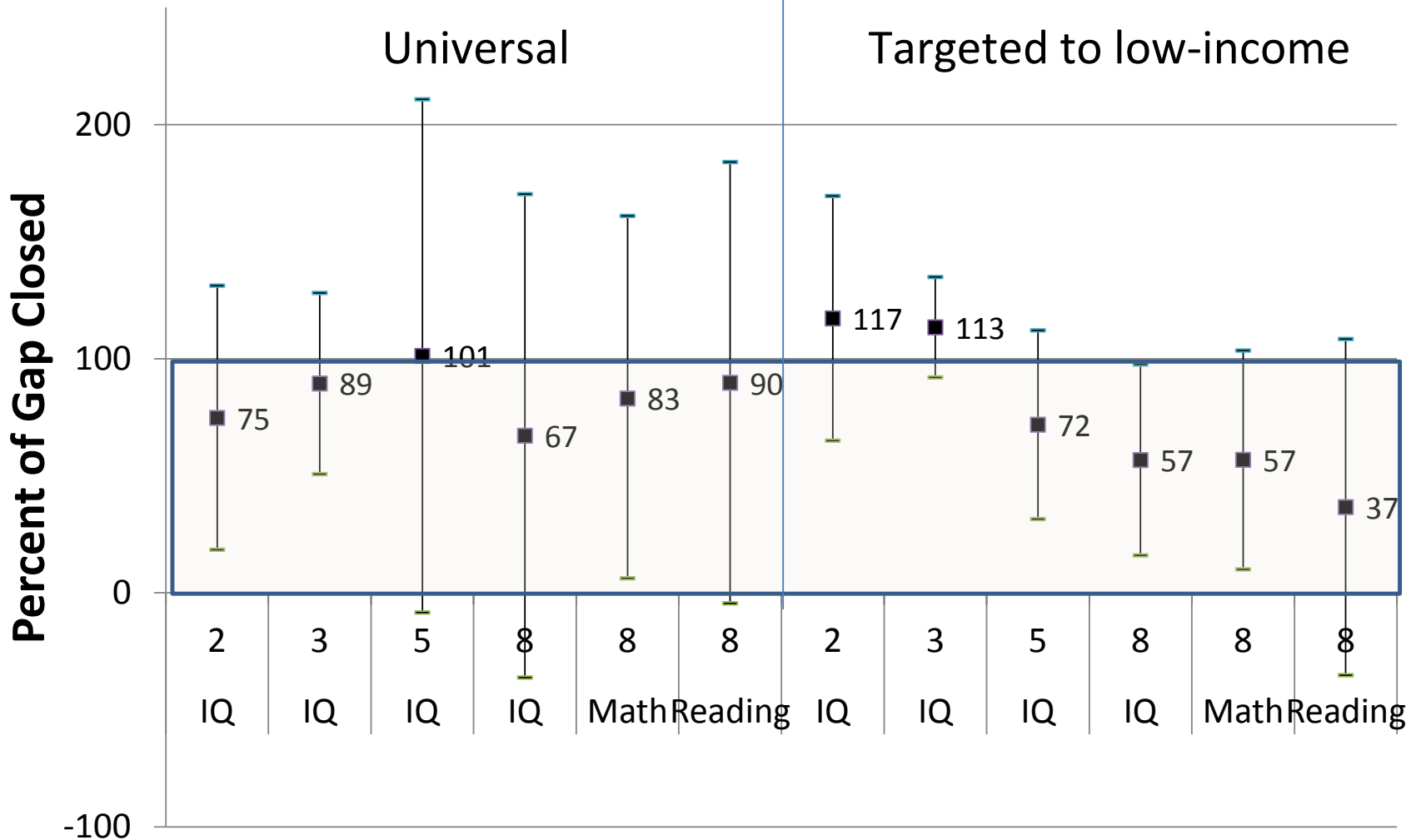
Conclusions

- Targeted program
  - Evidence that large, persistent reductions in cognitive and achievement gap can be achieved.

- Universal program
  - No evidence of persistent benefit to higher-income children.
  - Could be because control-group parents already choose high-quality alternatives.

IQ effects larger for lower-income

Outcome		A	B	C
Age 1 IQ (n=330)	Treatment	0.109 (0.132)	0.112 (0.133)	0.065 (0.177)
	Low income		-0.037 (0.122)	-0.072 (0.171)
	Treatment x (Low income)			0.097 (0.253)
Age 2 IQ (n=322)	Treatment	0.793*** (0.160)	0.878*** (0.223)	0.433* (0.219)
	Low income		-0.875*** (0.244)	-1.181*** (0.270)
	Treatment x (Low income)			0.872** (0.280)
Age 3 IQ (n=328)	Treatment	0.903*** (0.147)	1.001*** (0.181)	0.323 (0.210)
	Low income		-1.017*** (0.192)	-1.482*** (0.240)
	Treatment x (Low income)			1.319*** (0.308)

Coefficient (within site correlation corrected SE). Significance: *0.10 **0.05 ***0.01.
All models also condition on child gender, birth weight, gestational age at birth, neonatal health index and site indicators. IHDP HLBW sample with ECLS-B weights.

Age-8 achievement effects also larger for low-income

Outcome		A	B	C
Reading (n=308)	Treatment	-0.116 (0.209)	-0.041 (0.261)	-0.456 (0.267)
	Low income		-0.643*** (0.156)	-0.936*** (0.123)
	Treatment x (Low income)			0.804*** (0.184)
Math (n=312)	Treatment	0.120 (0.149)	0.187 (0.206)	-0.137 (0.197)
	Low income		-0.594* (0.257)	-0.830** (0.281)
	Treatment x (Low Income)			0.636** (0.224)

Coefficient (within site correlation corrected SE). Significance: *0.10 **0.05 ***0.01.
All models also condition on child gender, birth weight, gestational age at birth, neonatal health index and site indicators. IHDP HLBW sample with ECLS-B weights.

Gap closing estimates

Age and outcomes	High-low income gap		Treatment effect for higher-income	Treatment* Low-income interaction	% Gap closed from universal program	% Gap closed from targeted program
	IHDP mean difference	α_1	α_2	α_3	α_3/α_1	$(\alpha_2+\alpha_3)/\alpha_1$
IQ at 12 months	0.24* (0.14)	0.01 (0.18)	0.11 (0.18)	0.04 (0.25)	159 (100545)	999 (182168)
IQ at age 2	1.35*** (0.18)	1.09** (0.28)	0.46* (0.23)	0.82** (0.30)	74.8** (22.2)	117.2*** (20.8)
IQ at age 3	1.76*** (0.17)	1.42*** (0.24)	0.34 (0.21)	1.28*** (0.31)	89.4*** (15.2)	113.4*** (8.4)
IQ at age 5, Kindergarten	1.08*** (0.14)	0.76** (0.21)	-0.22 (0.22)	0.77** (0.22)	101.2* (43.7)	71.8*** (15.8)
IQ at age 8, grade 3	1.03*** (0.15)	0.77*** (0.17)	-0.08 (0.29)	0.52 (0.34)	67.1 (40.9)	56.7** (15.9)
Reading at age 8, grade 3	1.08*** (0.18)	0.82*** (0.13)	-0.44 (0.27)	0.74** (0.23)	89.7* (37.4)	36.6 (28.6)
Math at age 8, grade 3	0.96*** (0.19)	0.76** (0.24)	-0.20 (0.19)	0.64** (0.22)	83.6** (30.6)	56.8** (18.6)