The Only Child

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Motivation

There are now more only children worldwide than ever before:

- ▶ 22% of all U.S. families (Pew Research Center, 2015)
- ▶ 70% of all urban families in China (NBS China, 2007)
- ▶ 21% of Danish families (Statistics Denmark, 2020)

Would only children do better or worse if they had siblings?

- ▶ **May do better** — they do not share family resources (Becker and Lewis, 1973; Becker and Tomes, 1976)
- ▶ **May do worse** — they lack younger siblings to teach or socialize with (Zajonc and Markus, 1975; Zajonc, 1976)

Quantifying the effect of siblings is difficult due to selection:

- ▶ Families with one child may differ in values, stability, and other unobservables.

This Paper

- ▶ What is the effect of siblings on firstborns?
  - ▶ Would the cognitive and non-cognitive development of firstborn children improve or worsen if they had siblings?

- ▶ Natural experiment: in-vitro fertilization (IVF).
  - ▶ Focus on families who underwent the procedure for a second child, comparing first-borns in families whose procedure succeeded versus failed.

- ▶ Estimate effects on school performance, personality, and well-being using a near-universe of Danish firstborns whose parents underwent IVF.
  - ▶ Math, language, conscientiousness, agreeableness, emotional stability, and happiness.

Literature and Contribution

1. Studies exploiting China's one-child policy to estimate the effect of having siblings
   - ▶ H. Li et al. (2008); Rosenzweig & Zhang (2009); Qian (2009); Cameron et al. (2013); Liu (2014); B. Li & Zhang (2017); Guo et al. (2020); Xiao (2024)

We provide the first evidence from a developed country, holding the socioeconomic context fixed.

2. Studies on additional siblings (≥ 2), leveraging twin births and sex composition
   - ▶ Conley & Glauber (2006); Black et al. (2005); Åslund & Grönqvist (2010); Angrist et al. (2010); De Haan (2010)

We provide evidence on the first-sibling margin, where both resource dilution and social-learning effects are likely strongest.

3. Birth order literature comparing earlier-born to later-born children
   - ▶ Black et al. (2011); Conley & Glauber (2006); Gary-Bobo et al. (2006); Kantarevic & Mechoulan (2006); Kristensen & Bjerkedal (2007); Booth & Kee (2009); De Haan (2010); Houmark (2023)

**We shed light on the "only-child handicap" (Zajonc & Markus, 1975).**

In Vitro Fertilisation

- ▶ Couples who have trouble conceiving can attempt IVF.
- ▶ Treatment success has a random component.
  - ▶ Uncorrelated with firstborn and parent observables conditional on mother's age.
- ▶ Natural experiment:
  - ▶ First children whose parents have a successful treatment get a sibling.
  - ▶ First children whose parents have an unsuccessful treatment are more likely to remain the only child.
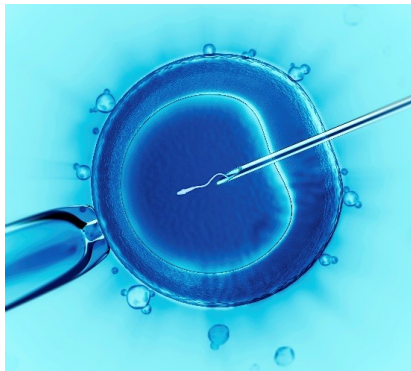
Source: CDC

In Vitro Fertilisation
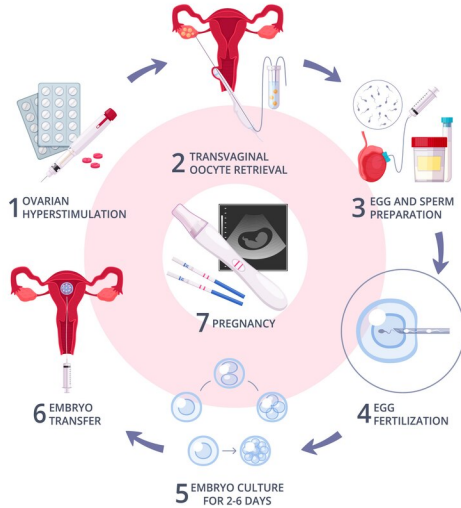
Source: Freepik

Data

- ▶ Danish IVF register: date of treatment, treatment outcome, and date of birth.
- ▶ Administrative registers: parent education, age, marital status, number of children, labor market attachment, and annual earnings.
- ▶ Education registry with scores from nationwide school exams.
- ▶ Nationwide surveys of primary and secondary school students.

Outcomes

▶ **Cognitive outcomes:** children take multiple nationwide tests:
  ▶ 4 tests in reading (grades 2, 4, 6, and 8) and 2 tests in math (grades 3 and 6).

▶ **Noncognitive outcomes:** children respond to nationwide school surveys that measure three of the Big Five personality traits and wellbeing (grades 4 through 9):
  ▶ Conscientiousness
  ▶ Agreeableness
  ▶ Emotional stability
  ▶ Openness to experience
  ▶ Extroversion

We standardize the outcomes by cohort and average per subject or trait.

Sample

▶ We select all mothers with one child who receive IVF treatment for a second child.

▶ This leaves us with **11,000** and **7,500** first children with cognitive and non-cognitive outcomes, respectively.

▶ To compare them with a representative sample we select all mothers with first-born children born around the same time as the focal children in the IVF sample.

▶ This leaves us with about **340,000** and **225,000** representative children with cognitive and non-cognitive outcomes, respectively.

Identification Framework

Treatment and instrument:

$$S = \begin{cases} 1 & \text{if first child has any siblings,} \\ 0 & \text{if first child remains an only child,} \end{cases} \qquad Z = \begin{cases} 1 & \text{if first IVF succeeds,} \\ 0 & \text{if first IVF fails.} \end{cases}$$

Potential outcomes:

$$Y_z(s): \text{ First child's school outcome if } Z = z, \ S = s.$$

Each child has three relevant potential outcomes:

$$Y_1(1), \quad Y_0(0), \quad Y_0(1).$$

Compliers $(C=1)$: no siblings after a failed first IVF attempt.
Always-takers $(C=0)$: have siblings regardless of the first attempt outcome.

Assumptions and Identification

Assumptions:

A1. Independence: $Y_1(1), Y_0(0), Y_0(1), C \perp Z$.

▶ Support: success not correlated with parental pre-procedure labor outcomes or firstborn birth outcomes, conditional on mother's age. `Balance`

A2. Exclusion: $Y_1(1) = Y_0(1)$.

▶ Outcomes should not depend on when or how the second child is conceived.

Standard LATE argument (Angrist & Imbens, 1995):

$$\frac{\mathsf{E}[Y|Z{=}1] - \mathsf{E}[Y|Z{=}0]}{\mathsf{E}[S|Z{=}1] - \mathsf{E}[S|Z{=}0]} = \mathsf{E}[Y_1(1) - Y_0(0) \mid C{=}1].$$

Raw Relationship Between Having Siblings and Child Outcomes

Table 1: Associations between having siblings and school outcomes

	Math Test	Reading Test	Agreeable	Consc.	Emotional Stability	School Happiness
Panel A: Representative sample						
Having siblings	0.171	0.090	0.074	0.122	0.114	0.115
	(0.005)	*(0.004)*	*(0.005)*	*(0.005)*	*(0.005)*	*(0.005)*
Observations	256,992	339,281	224,486	224,571	224,537	224,522
Panel B: IVF sample						
Having siblings	0.088	0.054	0.030	0.051	0.042	0.074
	(0.023)	*(0.020)*	*(0.021)*	*(0.022)*	*(0.022)*	*(0.021)*
Observations	8,308	10,906	7,689	7,666	7,567	7,783

Note: Unconditional outcome differences between first-born children with and without siblings. Standard errors in parentheses.

Causal Estimates

Table 2: First-stage and second-stage estimates

	Math Test Sample	Reading Test Sample	Agreeable Sample	Consc. Sample	Emotional Stability Sample	School Happiness Sample
Panel A: First-stage						
Success	0.344	0.338	0.324	0.323	0.323	0.324
	(0.005)	*(0.005)*	*(0.006)*	*(0.006)*	*(0.006)*	*(0.006)*
Observations	8,308	10,906	7,689	7,666	7,567	7,783
Panel B: Second-stage						
Having siblings	-0.054	-0.049	-0.038	-0.025	-0.075	-0.118
	(0.069)	*(0.059)*	*(0.068)*	*(0.071)*	*(0.071)*	*(0.068)*
Observations	8,308	10,906	7,689	7,666	7,567	7,783

Note: Panel A–first-stage estimates of the effect of parents' first IVF attempt succeeding on the likelihood that the first-born has at least one sibling (complier share). Panel B—IPW estimates of the effect of having siblings on standardized outcomes. Standard errors in parentheses.

Improving Identification

Our causal estimates rule out the OLS estimates, though some limitations remain.

- ▶ Estimates are relatively imprecise.
- ▶ Identification covers only compliers.
- ▶ Potential exclusion violations may arise if age gaps between siblings matter.

We improve upon this by exploiting variation not only in the *first* IVF attempt, but in the *entire sequence* of IVF procedures.

- ▶ Identify effects for firstborns whose sibling status depends on entire IVF sequences.
    1. Estimates apply to a broader population.
    2. A stronger "first-stage" yields more precise estimates.
    3. The presence of later-born siblings in the control group becomes less relevant.

Leveraging such variation without introducing selection is challenging, since the decision of how many procedures to undergo may itself be selective.

Intuition

Treatment group: firstborns whose parents' first IVF for a second child succeeded.

Old control group: firstborns whose parents' first IVF failed.

New control group: firstborns whose parents' entire IVF sequence failed.

▶ Issue: families trying more times are less likely to end up never succeeding, so they are underrepresented.

But for parents who never succeeded, we observe how many attempts they made, and we can also identify success rates per attempt.

▶ We can identify exactly how likely a never-succeeder was to never succeed ex-ante.

▶ Weight families appropriately to correct selection: greater weight if tried more

Formal argument: latent types characterize how many IVF attempts parents would make if failures continue, and whether they would conceive regardless of success.

▶ Key assumption: success after embryo insertion is independent of types.

Full argument

Improved Causal Estimates

Table 3: Improved first-stage and second-stage estimates

	Math Test Sample	Reading Test Sample	Agreeable Sample	Consc. Sample	Emotional Stability Sample	School Happiness Sample
Panel A: First-stage						
Success	0.555	0.546	0.537	0.538	0.537	0.538
	(0.008)	*(0.008)*	*(0.010)*	*(0.010)*	*(0.011)*	*(0.010)*
Observations	5,961	7,783	5,379	5,350	5,283	5,446
Panel B: Second-stage						
Having siblings	-0.024	-0.006	-0.007	-0.008	-0.016	-0.031
	(0.045)	*(0.035)*	*(0.045)*	*(0.047)*	*(0.049)*	*(0.042)*
Observations	5,961	7,783	5,379	5,350	5,283	5,446

Note: Panel A reports first-stage estimates of the effect of parents' IVF attempts succeeding on the likelihood that the first-born has at least one sibling (relier share). Panel B reports the second-stage estimates of the effect of having siblings on standardized outcomes for reliers. Standard errors in parentheses.

Summary

► We find little evidence that siblings affect personality traits or school performance.

► All estimated effects are small and statistically insignificant.

► When examining heterogeneity in the only-child effect, the estimates remain remarkably stable across family income, fertility-related health conditions, maternal age, and the child's age and gender.

► Observed differences between only children and others likely reflect selection rather than causal effects of having siblings.

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Balance

	Success Mean (1)	Failure Difference (2)	Conditional Difference (3)
Female child	0.49	0.01	0.01
IVF child	0.50	0.03	0.01
Child weight (kg)	3.52	0.01	0.01
Child length (cm)	52.05	-0.00	0.03
Mother age	33.41	-1.12	-0.03
Mother college	0.52	-0.00	0.02
Mother income	0.21	-0.00	0.01
Mother work	0.93	0.01	0.01
Father age	35.87	-1.07	0.00
Father college	0.37	-0.01	0.01
Father income	0.27	-0.00	0.01
Father work	0.91	0.00	-0.00
Joint p-value		0.00	0.38

Note: Observations–10,906. Success probability–0.30. "Failure Difference" compares families whose first IVF attempt succeeded versus failed. "Conditional Difference" adjusts for parents' age (and squares) and treatment year indicators using inverse probability weights.

Back

Model

Families differ in two unobserved characteristics:

- ▶ "Willingness" to undergo IVF, $W \in \{1, \ldots, \overline{w}\}$
  - ▶ Would undergo W IVF procedures for the second child if all previous attempts failed.
- ▶ "Reliance" on IVF, $R \in \{0, 1\}$
  - ▶ Would have no second child if all IVF attempts failed ($R = 1$).

Observables:

- ▶ IVF attempt j success indicator: Z_j
- ▶ Number of realized attempts: $A = \min\left(\{j : Z_j = 1\} \cup \{W\}\right)$
- ▶ Second-child indicator: $S = \max(Z_A, 1 - R)$

Assumption:

A3. Sequential Independence: $Y_1(1), Y_0(0), Y_0(1), W, R \perp Z_j \mid A > j$.

- ▶ Among those who attempt IVF j times, jth attempt success is as good as random.

Back

$$W = 1$$
(willing to try once)

$$Z_1 = 1$$

$$Z_1 = 0$$

Simple World: Max 2 Procedures, All Reliers

$W = 1$
(willing to try once)

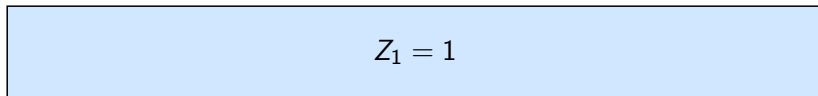$W = 2$
(willing to try twice)

$$Z_1 = 1$$

$$Z_1 = 1$$
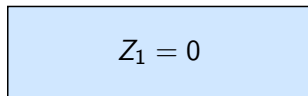
$$Z_1 = 0$$

$$Z_1 = 0, Z_2 = 1$$

$$Z_1 = 0, Z_2 = 0$$

Simple World: Max 2 Procedures, All Reliers

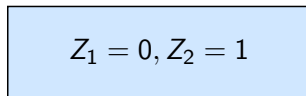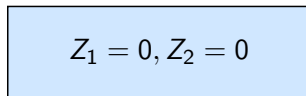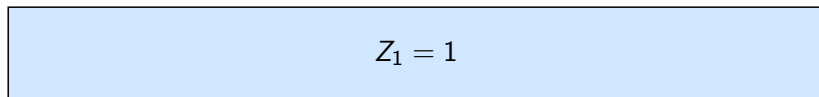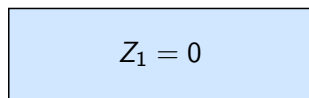| $W = 1$ (willing to try once)		$W = 2$ (willing to try twice)
$Z_1 = 1$	$\longleftrightarrow$	$Z_1 = 1$
$Z_1 = 0$	$\longleftrightarrow$	$Z_1 = 0, Z_2 = 1$
	$\longleftrightarrow$	$Z_1 = 0, Z_2 = 0$

Simple World: Max 2 Procedures, All Reliers

Simple World: Max 2 Procedures, All Reliers (Back)

$W = 1$
(willing to try once)

$W = 2$
(willing to try twice)

$Z_1 = 1$ $\longleftrightarrow$ $Z_1 = 1$

$E[Y_1(1)|W = 1]$ $E[Y_1(1)|W = 2]$

$Z_1 = 0$ $\longleftrightarrow$ $Z_1 = 0, Z_2 = 1$

$E[Y_0(0)|W = 1]$

$E[Y_0(1)|W = 2]$

$\longleftrightarrow$

$Z_1 = 0, Z_2 = 0$

$E[Y_0(0)|W = 2]$
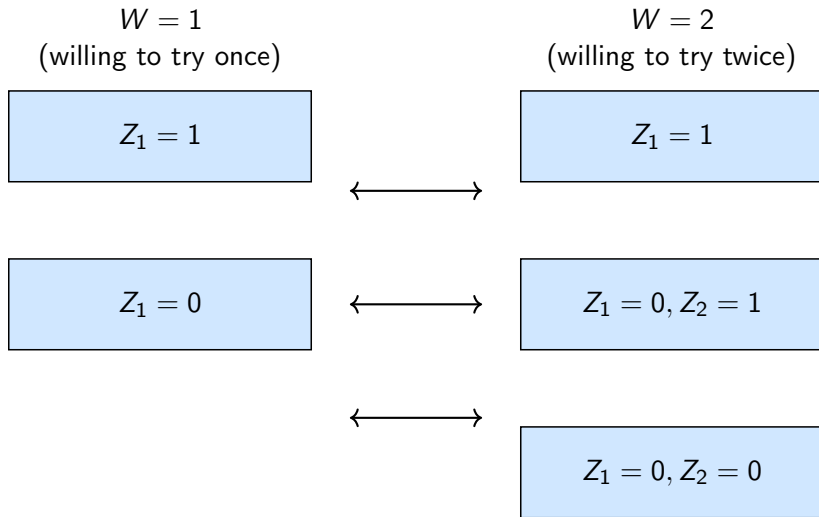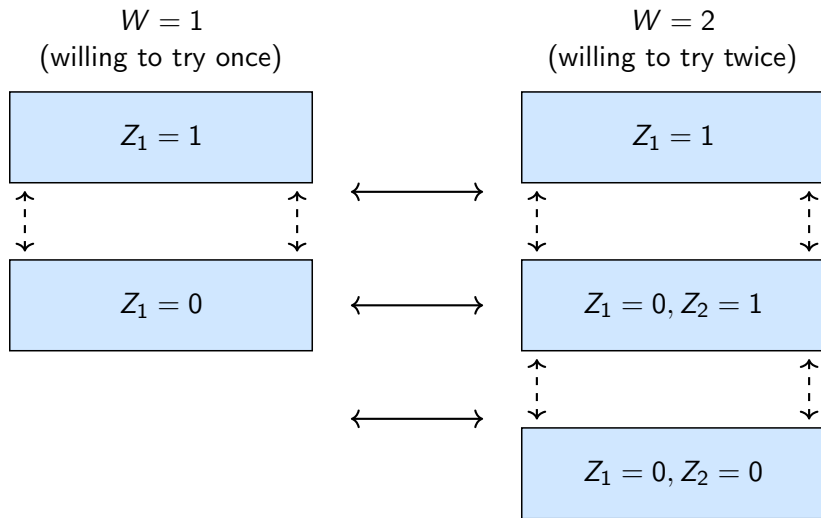
Simple World (Observed): Max 2 Procedures, All Reliers Back

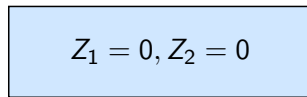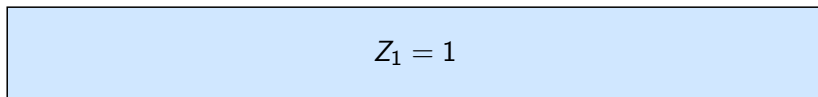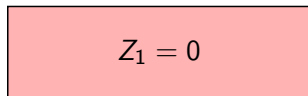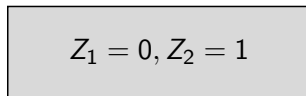$W = 1$
(willing to try once)

$W = 2$
(willing to try twice)

$$Z_1 = 1$$

$$Z_1 = 0$$

$$Z_1 = 0, Z_2 = 1$$

$$Z_1 = 0, Z_2 = 0$$

$W = 1$
(willing to try once)

$W = 2$
(willing to try twice)

$$Z_1 = 1$$

$E[Y_1(1)]$

$$Z_1 = 0$$

$E[Y_0(0)|W = 1]$

$$Z_1 = 0, Z_2 = 1$$

$E[Y_0(1)|W = 2]$

$$Z_1 = 0, Z_2 = 0$$

$E[Y_0(0)|W = 2]$

$W = 1$
(willing to try once)

$W = 2$
(willing to try twice)

$Z_1 = 1$

$E[Y_1(1)]$

$Z_1 = 0$

$E[Y_0(0)|W = 1]$

$Z_1 = 0, Z_2 = 1$

$E[Y_0(1)|W = 2]$

$Z_1 = 0, Z_2 = 0$

$E[Y_0(0)|W = 2]$

$W = 1$
(willing to try once)

$W = 2$
(willing to try twice)

$Z_1 = 1$

$E[Y_1(1)]$

$Z_1 = 0$

$E[Y_0(0)|W = 1]$

$Z_1 = 0, Z_2 = 1$

$E[Y_0(1)|W = 2]$

$Pr(W = 1) = \dfrac{}{}$

$Z_1 = 0, Z_2 = 0$

$E[Y_0(0)|W = 2]$