# The Only Child

Julius Ilciukas[1] Petter Lundborg[2] Erik Plug[3] Astrid Würtz Rasmussen[4]

[1] The Chinese University of Hong Kong
[2] Lund University
[3] University of Amsterdam
[4] Aarhus University

# 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 firstborns 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, where resource constraints play a smaller role and the socioeconomic context is held fixed.**

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

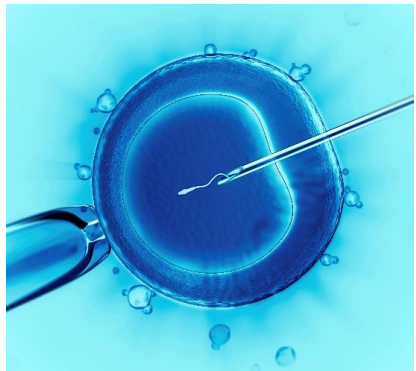
**We provide evidence on the first-sibling margin, where both resource dilution and social-learning effects are likely strongest.**

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).**

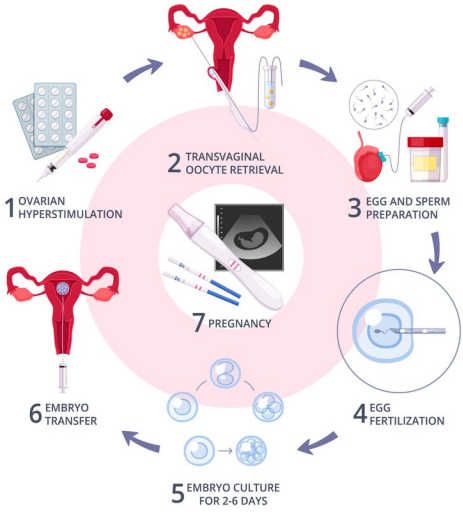
# In Vitro Fertilisation

- 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):

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

# 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.

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# 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: $A = \min(\{j : Z_j = 1\} \cup \{W\})$
- 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, $j$th attempt success is as good as random.

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# Simple World: Max 2 Procedures, All Reliers

Back

$W = 1$
(willing to try once)

$Z_1 = 1$

$Z_1 = 0$

# Simple World: Max 2 Procedures, All Reliers

Back

$W = 1$
(willing to try once)

$Z_1 = 1$

$Z_1 = 0$

$W = 2$
(willing to try twice)

$Z_1 = 1$

$Z_1 = 0, Z_2 = 1$

$Z_1 = 0, Z_2 = 0$

# Simple World: Max 2 Procedures, All Reliers

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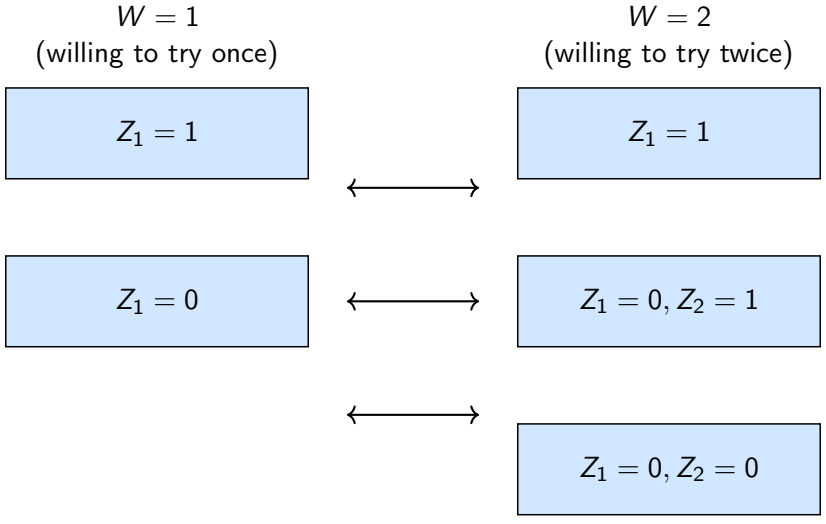

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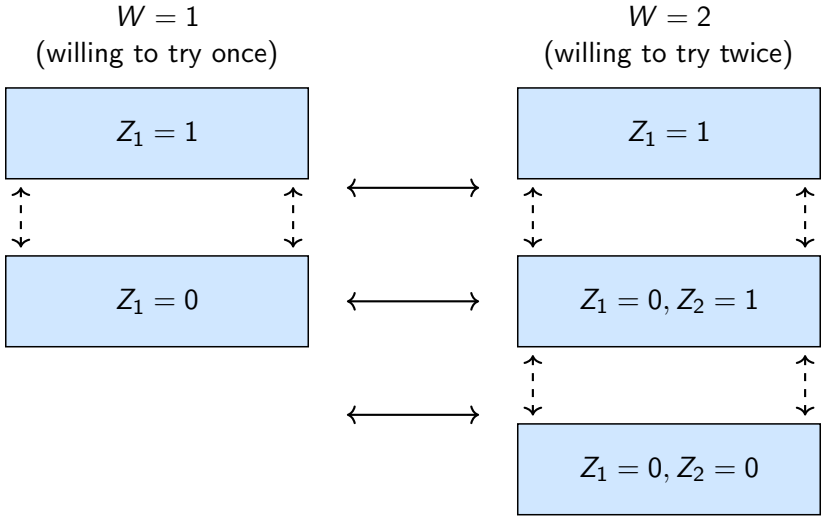

# Simple World: Max 2 Procedures, All Reliers

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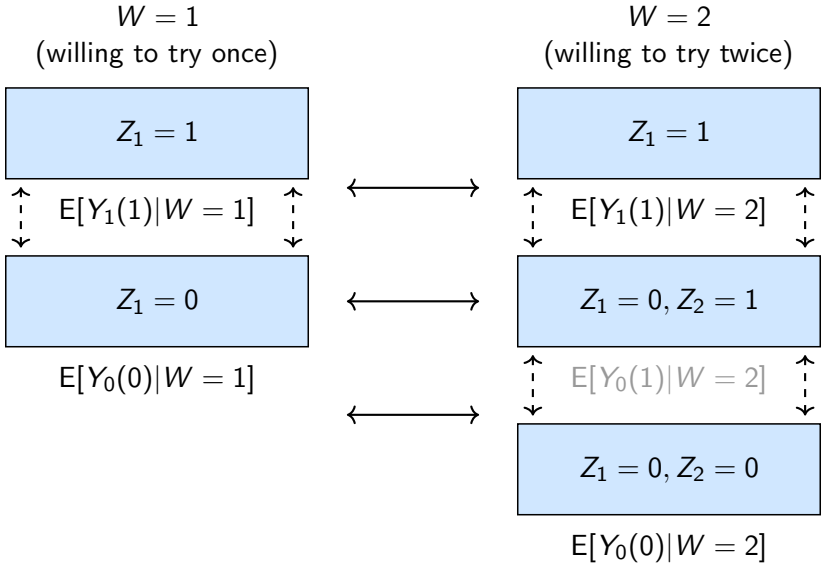

# Simple World (Observed): Max 2 Procedures, All Reliers

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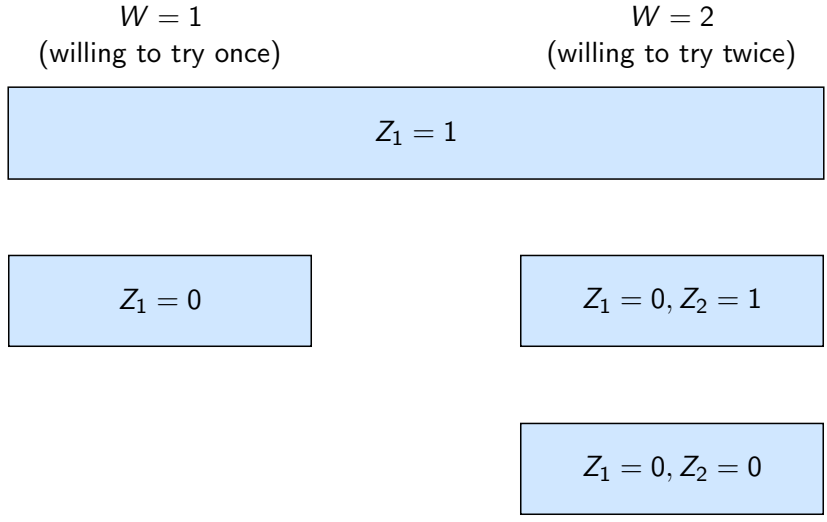

# Simple World (Observed): Max 2 Procedures, All Reliers

Back

$W = 1$
(willing to try once)

$W = 2$
(willing to try twice)

$Z_1 = 1$

$E[Y_1(1)]$

$Z_1 = 0$

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

$Z_1 = 0, Z_2 = 1$

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

$Z_1 = 0, Z_2 = 0$

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

# Simple World (Observed): Max 2 Procedures, All Reliers

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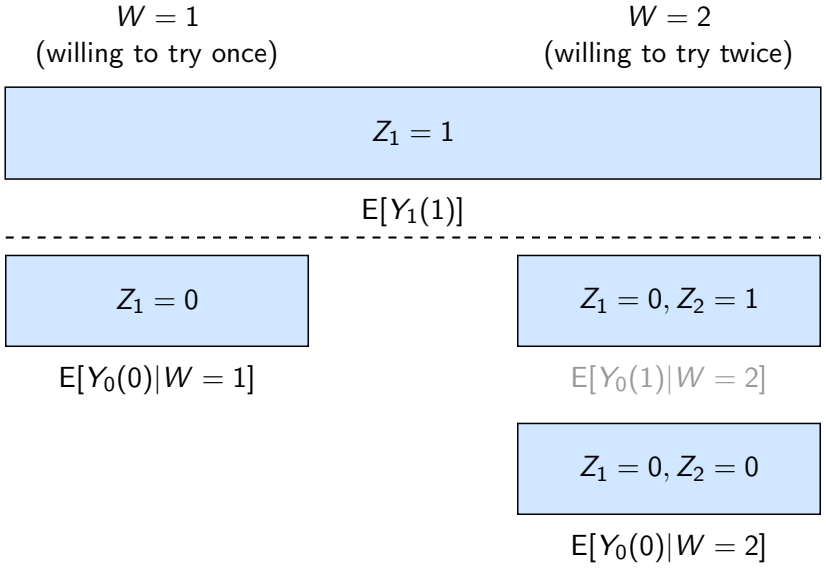

# Simple World (Observed): Max 2 Procedures, All Reliers

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