The Impact of Big Sisters

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Preliminary and incomplete. Please do not circulate.

Abstract
We estimate the impact of having an older sister (rather than an older brother) on early childhood development in a sample of rural Kenyan households with otherwise similar family structures. Older sibling gender is not related to household structure, subsequent birth spacing, or other observable characteristics, so we treat the presence of an older girl (as opposed to an older boy) as plausibly exogenous. Having an older sister improves younger siblings’ vocabulary and fine motor skills by more than 0.1 standard deviations. Impacts on physical development outcomes are concentrated near the bottom of the distribution. Impacts are not driven by changes in parental investments in younger children. Sisters do more direct stimulation of their younger siblings than brothers, and this leads to improvements in young children’s development outcomes.

JEL codes: O12, J13, J16, D13

Keywords: sisters, girls, girl effect, girl power, Family Care Indicators, early childhood, human capital, household structure, parental investments, natural experiment

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The findings, interpretations and conclusions expressed in this paper are entirely those of the authors, and do not necessarily represent the views of the World Bank, its Executive Directors, or the governments of the countries they represent.
1 Introduction

Investments in early childhood are a critical determinant of later life outcomes, and stimulating activities — for example, storybook reading and infant-directed speech — are one of the main ways that older family members invest in young children. A large literature examines the causes and consequences of parental investments in young children. However, parents are not the only caregivers in most human societies — much of that work is done by older siblings, particularly sisters (Lancy 2015). The impacts of older siblings’ investments in young children are not well understood.

We estimate the impact of older sisters on early childhood development. In a sample of rural Kenyan households that have one or two young children (aged three to six) and exactly one older sibling (aged seven to 14), we show that the gender of the older sibling is unrelated to household or community characteristics — and hence plausibly exogenous. We show that young children with one older sister are stimulated significantly more than those with one older brother. This pattern results from increased stimulation by older sisters, not by parents — so the results are not driven by changes in parental investments (as they might be, for example, if boys were favored over girls). Increased stimulation translates into improvements in child development. An aggregate index of language and motor development is 0.1 standard deviations higher when a young child’s older sibling is a sister and not a brother.

2 Conceptual Framework

Consider a unitary household $i$ comprising a parent, an older (i.e. school-aged) child, and a younger (not yet school-aged) child. Let $g_i$ be an indicator equal to one if the older sibling in household $i$ is female. Familial investments in children increase child ability, leading to higher incomes in adulthood. The parent divides their time between household production and investing in their two children, and the older child divides their time between schoolwork (i.e. investing in their own human capital) and stimulating the younger sibling.
The younger child’s human capital depends only on investments by older family members — since preschool-aged children do not make active choices (e.g. how hard to work in school) that increase human capital. The younger child’s human capital production function is given by \( h_y(I_y) \); it is assumed to be increasing and concave with \( h'_y(I_y) > 0 \), \( h''_y(I_y) < 0 \), and \( \lim_{I_y \to 0} h'_y(I_y) = \infty \). \( I_y = p_y + \delta_i o_y \) where \( p_y \) is the parent’s investment in her younger child, \( o_y \) is the older sibling’s investment in her younger sibling, and \( \delta_i < 1 \) indexes the productivity (with respect to human capital production) of investments made by the older sibling in household \( i \) (relative to the adults in household \( i \)). Thus, parents and older siblings are assumed to be perfect substitutes in the production of younger children’s human capital — though parents may have an absolute advantage. When \( \delta_i = 0 \), investments made by the older sibling do not improve the younger siblings’ human capital.

Older children exert effort in school, which increases their human capital. The older sibling’s human capital production function is given by \( h_o(E_o, p_o) \) where \( E_o \) is the child’s level of effort in school and \( p_o \) is the parent’s investment in the older child. We assume \( h_o(E_o, p_o) \) is additively separable in \( E_o \) and \( p_o \), and that the functional form is identical for all older siblings up to a parameter \( \lambda_i \) that indexes expected returns to human capital for the older sibling in household \( i \).\(^1\) Thus,

\[
h_o(E_o, p_o) = \lambda_i [f(E_o) + g(p_o)]
\]

where \( f(E_o) \) and \( g(p_o) \) are increasing and concave functions satisfying Inada conditions.

The parent divides one unit of time between household production (i.e. labor supply) and stimulating her children: \( L_p + p_o + p_y = 1 \) where \( L_p \) is time spent on household production, \( p_o \) is investment in the older child, and \( p_y \) is time invested in the younger child. The parent’s output is characterized by the production function \( y(L_p) \). We assume that \( y'(L_p) > 0 \), \( y''(L_p) < 0 \), and \( \lim_{L_p \to 0} y'(L_p) = \infty \).

\(^1\)Cases where child effort and parental investment are complements have an intuitive appeal — for example, if parents assist school-aged children with their homework. However, such complementaries allow for the possibility of multiple equilibria. For this reason, we focus our analysis on the determinants of investments in younger children and simplify the rest of the environment as much as possible.
Household utility is given by

\[ U = y(L_p) + \lambda_i f(E_o) + \lambda_i g(p_o) + h_y(I_y) \]  

(2)

where

\[ L_p = 1 - p_o - p_y, \]  

(3)

\[ E_o = 1 - o_y, \]  

(4)

and

\[ I_y = p_y + \delta_i o_y. \]  

(5)

If an interior solution \((p_o^*, p_y^*, o_y^*)\) exists, the following are true at the optimum:

\[ y'(1 - p_o^* - p_y^*) = \lambda_i g'(p_o^*) = h_y'(p_y + \delta_i o_y) \]  

(6)

and

\[ \lambda_i f'(1 - o_y^*) = \delta h_y'(p_y + \delta_i o_y). \]  

(7)

Two corner solutions are also possible: at the optimum, either \(o_y^*\) or \(p_y^*\) (but not both) might be equal to 0. When stimulation by older siblings does not improve younger siblings' human capital (i.e. when \(\delta_i = 0\)), older siblings will devote all their time to building their own human capital by setting \(o_y^*\) to 0. On the other hand, if older children are sufficiently proficient at stimulating their younger siblings, parents may delegate this task to them by setting \(p_y^* = 0\).

In this framework, there are two reasons older girls might stimulate their younger siblings more than older boys: girls might be better at producing younger siblings' human capital with a given level of (time) investment, or the return to human capital might be lower for girls than boys.\(^2\) We consider each case in turn by allowing \(\delta_i\) or \(\lambda_i\) to vary while holding

\(^2\)It is apparent that one could extend the model to introduce other reasons that girls might spend more time stimulating younger siblings. If a model of occupational specialization, girls who expect to specialize in home production might see a high return to the development of home-specific human capital (such as
the other parameter constant; we then characterize predictions when both mechanisms are at play.

2.1 Gender Differences in Productivity

We begin by considering the consequences of gender differences in $\delta_i$, the parameter indexing the productivity of older siblings’ investments in young children’s human capital. We let $\delta_i$ differ by gender while $\lambda_i$ (the older siblings’ return to education) does not. Specifically, let

$$
\delta_i(g_i) = \begin{cases} 
\delta_G & \text{if } g_i = 1 \\
\delta_B & \text{if } g_i = 0 
\end{cases} 
$$

(8)

for some $\delta_G > \delta_B$, and let $\lambda_i(g_i) = \lambda_i(1) = \lambda_i(0) = \bar{\lambda}$ for all $i$. Let $p_o^*(\lambda_i(g_i), \delta_i(g_i))$ denote the optimal level of parental investment in the older child as a function of the older child’s gender for a given set of assumptions about $\lambda_i(g_i)$ and $\delta(g_i)$. Thus, $p_o^*(\bar{\lambda}, \delta_G)$ is the optimal level of $p_o^*$ when the older sibling is a girl (i.e. when $g_i = 1$), conditional on our assumption that $\lambda_i(g_i) = \bar{\lambda}$ for all $i$ and $\delta_i(1) = \delta_G$. Similarly, $p_o^*(\bar{\lambda}, \delta_B)$ is the optimal level of $p_o^*$ when the older sibling is a boy. Define $p_y^*(\bar{\lambda}, \delta_k), o_y^*(\bar{\lambda}, \delta_k), L_p^*(\bar{\lambda}, \delta_k), E_o^*(\bar{\lambda}, \delta_k)$, and $L_y^*(\bar{\lambda}, \delta_k)$ analogously for $k = A, B$.

In Proposition 1, we show that when older sisters are more productive than older brothers (when it comes to improving younger siblings’ human capital), children with older sisters receive more stimulation overall. Parents with an older child who is a girl substitute away from investing in their time in early childhood stimulation, investing more in older children’s human capital and increasing their own their own labor supply in consequence.

An equilibrium is fully characterized by $p_y^*, p_o^*$, and $o_o^*$. The optimal $L_p^*, E_o^*$, and $L_y^*$ are then defined by Equations 6 and 7.

3 An equilibrium is fully characterized by $p_y^*, p_o^*$, and $o_o^*$. The optimal $L_p^*, E_o^*$, and $L_y^*$ are then defined by Equations 6 and 7.
Impacts on older siblings’ behavior are ambiguous and depend on the functional forms of the production functions.

**Proposition 1.** Let

\[
\delta_i = \begin{cases} 
  \delta_G & \text{if } g_i = 1 \\
  \delta_B & \text{if } g_i = 0 
\end{cases}
\]  

(9)

for some \( \delta_G > \delta_B \geq 0 \), and let \( \lambda_i = \bar{\lambda} \) for all \( i \). Then, \( I^* (\bar{\lambda}, \delta_G) > I^* (\bar{\lambda}, \delta_B) \), \( p_y^* (\bar{\lambda}, \delta_G) > p_y^* (\bar{\lambda}, \delta_B) \), \( p_y^* (\bar{\lambda}, \delta_G) < p_y^* (\bar{\lambda}, \delta_B) \), and \( L_p^* (\bar{\lambda}, \delta_G) > L_p^* (\bar{\lambda}, \delta_B) \).

**Proof.** See Appendix.

Thus, gender differences in older children’s effectiveness as caregivers translate into empirical predictions about parents’ responses. We consider the case of gender differences, but the proof is equally valid if other observable factors (e.g. older sibling age) generate systematic differences in \( \delta_i \): optimizing parents will delegate more early childhood stimulation to more competent siblings caregivers, substituting toward other activities that cannot be done by their older children. Importantly, this result relies on the assumption that parents hold accurate beliefs about \( \delta_i \). If parents do not realize that older children’s investments in their siblings improve younger children’s human capital, they cannot respond optimally.

### 2.2 Gender Differences in the Return to Human Capital

Next, we consider the possibility that the returns to human capital are lower for girls than for boys — for example, because of their lower labor force attachment — by letting \( \lambda_i = \lambda_B \) for boys and \( \lambda_i = \lambda_F < \lambda_B \) for older girls.\(^4\) We initially assume that returns only differ for older siblings, reflecting the empirical fact that we do not observe gender differences in early childhood stimulation. Below, we consider an extension of the model that allows the return to human capital investment to differ by gender for both older and younger siblings.

\(^4\)We are making a positive rather than a normative statement: education is equally important for boys and girls. However, households may invest less in girls’ education if they perceive lower labor market returns for girls — whether or not the overall social returns to education differ by gender.
Paralleling our analysis in Section 3.1, we let \( p^*_o(\lambda_G, \bar{\delta}) \) and \( p^*_o(\lambda_B, \bar{\delta}) \) denote the optimal levels of parental investment in older girls and boys, respectively. Other (optimal) parameters are defined analogously. In Proposition 2, we show that when returns to human capital are lower for girls than for boys, children with older sisters receive more stimulation overall. Thus, both mechanisms predict the same overall treatment effect of older sisters on younger siblings. However, the mechanisms driving the impact of older sisters are different. When returns to older siblings’ human capital differ by gender, both parents invest less in older sisters (relative to older brothers) and older sisters also invest less in their own human capital and more in the human capital of their younger siblings.

**Proposition 2.** Let

\[
\lambda_i = \begin{cases} 
\lambda_G & \text{if } g_i = 1 \\
\lambda_B & \text{if } g_i = 0
\end{cases}
\]

for some \( \lambda_G < \lambda_B \), and let \( \delta_i = \bar{\delta} > 0 \) for all \( i \). Then, \( I^*(\lambda_G, \bar{\delta}) > I^*(\lambda_B, \bar{\delta}) \), \( L^*_p(\lambda_G, \bar{\delta}) > L^*_p(\lambda_B, \bar{\delta}) \), \( p^*_o(\lambda_G, \bar{\delta}) < p^*_o(\lambda_B, \bar{\delta}) \), \( o^*_y(\lambda_G, \bar{\delta}) > o^*_y(\lambda_B, \bar{\delta}) \), and \( E^*_o(\lambda_G, \bar{\delta}) < E^*_o(\lambda_B, \bar{\delta}) \).

**Proof.** See Appendix.

### 2.3 Extensions to the Model

1. Characterize \( \lambda_G < \lambda_B \), \( \delta_i = 0 \) case (or equivalent case where parents do not perceive the impact of older siblings’ investments in young children). Optimal \( o^*_y = 0 \): older siblings specialize in increasing their own human capital. \( \lambda_G < \lambda_B \Rightarrow p^*_o(\lambda_G, \bar{\delta}) < p^*_o(\lambda_B, \bar{\delta}) \) and \( p^*_y(\lambda_G, \bar{\delta}) > p^*_y(\lambda_B, \bar{\delta}) \).

2. Allowing return to human capital to differ by gender for younger siblings.

3. Both mechanisms at the same time. Proofs can be used sequentially, so predictions on investment in young children, parental labor supply will go through and others should be ambiguous.

4. Make a summary table of predictions.
3 Data

Our sample includes data on 552 households from 73 rural communities in western Kenya. Data were collected during the baseline survey that preceded an impact of a pre-literacy intervention. Households living within 750 meters of the local government primary school were included in the sample if they had children between three and six years old. Here, we restrict attention to those households which also had exactly one older child between the ages of seven and 14. Our treatment of interest is an indicator for having an older child who is female.

Our data set includes information on household and parental characteristics (e.g. household assets and mother’s education) as well as multiple measures of child development and familial investments in young children. We consider two main developmental outcomes that can be measured in preschool-aged children: vocabulary and fine motor skills. Both are measured through direct child assessment.

Our vocabulary index combines includes three sub-scales: expressive vocabulary and receptive vocabulary in English and Luo, all of which are measured through direct child assessment. Receptive vocabulary is the ability to understand words, while expressive vocabulary is the ability to produce words — for example, to identify familiar objects. Children begin developing receptive vocabulary before they begin to express themselves through speech (Fernald, Prado, Kariger and Raikes 2017). To measure receptive vocabulary in English (one of Kenya’s national language and the primary language of instruction at upper levels of primary school) and Luo (a Nilotic language that is the mother tongue of all of the children in our sample), we adapted items from the British Picture Vocabulary Scale, a version of the Peabody Picture Vocabulary Test suitable for speakers of British or Commonwealth English (Dunn and Dunn 1997, Dunn, Dunn and Styles 2009, Knauer, Kariger, Jakiela, Ozier and Fernald 2019b). We assessed expressive vocabulary through a 37-item assessment developed and validated for the EMERGE study (Knauer et al. 2019b).

We assessed children’s fine motor skills using a subset of items from the Malaw
opmental Assessment Test (Gladstone, Lancaster, Umar, Nyirenda, Kayira, van den Broek and Smyth 2010). Specifically, the survey included six questions from the MDAT fine motor sub-scale that showed high predictive power (in terms of other development outcomes) in a pilot study (Knauer, Jakiela, Ozier, Aboud and Fernald 2019a). The items measure young children’s ability to build simple structures (e.g. a tower) with blocks and to use a pencil to make elementary drawings (e.g. a circle). Both vocabulary and fine motor indices are converted into age-normalized z-scores. We then average the individual (z-score) components to construct an overall measure of child development.

To understand the mechanisms through which sibling gender impacts child development, we collected data on early childhood stimulation using an expanded version of the Family Care Indicators (FCI) questionnaire (Hamadani, Tofail, Hilalay, Huda, Engle and Grantham-McGregor 2010, Kariger, Frongillo, Engle, Britto, Sywulka and Menon 2012). The FCI asks about six types of stimulating activities: for example, reading, singing, storytelling, and physical play. We expanded this set to include additional stimulating activities more appropriate for slightly older children: for instance, teaching a child letters or English words (Knauer et al. 2019a). Based on extensive piloting, we also expanded the questionnaire to better capture the full range of family members who engage in early childhood stimulation. While the original instrument asks about stimulation by a child’s mother, father, and by other adults, we also ask about stimulating activities by older sisters, older brothers, and grandparents.

4 Analysis

4.1 Empirical Strategy

To estimate the impact of big sisters on child development, we assume that child gender is plausibly exogenous. We estimate the regression equation:

$$Y_i = \alpha + \beta \text{Sister}_i + \varepsilon_i$$

(11)
where $Sister_i$ is an indicator equal to one if the older sibling in household $i$ is female. Parents cannot control the sex of any given child, and households in our study area have little access to sex-selection technologies — so gender is not explicitly endogenous. Nevertheless, our estimates of the treatment effect of older sisters will be biased if $Sister_i$ is correlated with any (observed or unobserved) covariates that also predict outcomes. For example, if fathers were less likely to be present in households with an older girl (Dahl and Moretti 2008) and fathers’ presence had a direct effect on child development outcomes, $\hat{\beta}$ would not capture the causal impact of having an older sister on child development. We test for this by comparing the observable characteristics of households with and without an older sister.

Summary statistics comparing households with an older sister to households with an older brother are presented in table 1. Households are broadly similar in terms of family structure, parental characteristics, and living conditions; and younger children are similar in terms of gender, age, and school enrollment. Older sisters and older brothers are also similar in age, suggesting comparable patterns of fertility and birth spacing in the two types of households. Since families with older sisters and older brothers look similar in terms of observable characteristics, we treat the gender of the older child as plausibly exogenous in our subsequent analysis.

### 4.2 The Impact of Big Sisters on Child Development

Kernel density estimates of our early childhood development index are presented in Figure 1. Negative z-scores are more common among young children with older brothers, and z-scores are more concentrated about zero among children with older sisters. The density functions are quite similar for z-scores above one. Thus, the graphical evidence suggests that poor early childhood development outcomes are less common in families with an older child who is female.

Regression estimates of the impact of older sisters on younger siblings’ development are reported in Table 2. Older sisters have large and statistically significant effects on their younger siblings. Estimates of Equation 11 suggest that young children with an older
sister score 0.129 standard deviations higher on our aggregate measure of early childhood development (p-value 0.035). In specifications that include controls for child gender, age (fixed effects for child age in months), mother’s education, and an index of household assets, the estimated impact of big sisters rises to 0.141 (p-value 0.023). Both coefficients are large in magnitude and developmentally meaningful. For comparison, the estimated effect is roughly equivalent to the difference in development between children whose mothers’ completed secondary school and those whose mothers’ only completed primary.\(^5\)

Quantile regressions of the early childhood development index on the indicator for having an older sister rather than an older brother are summarized in Figure 2. We estimate one regression for every quantile between 0.02 and 0.98. The pattern suggests that impacts are largest at the bottom of the distribution. For the lowest quantiles, the estimated treatment effects are large but imprecisely estimated. For quantiles between about 0.2 and 0.5, estimated treatment effects are positive and confidence intervals typically exclude zero. Above the median, estimated treatment effects are closer to zero and never statistically significant. Thus, results from quantile regressions formalize the evidence from the kernel density estimates: the treatment effects of sisters appear to be concentrated on the bottom half of the distribution.

In Panel B of Table 2, we decompose the underlying elements of the early childhood development index, estimating the treatment effect of big sisters on young children’s vocabulary and fine motor skills. Results show that having an older sister leads to improvements in both outcomes. In specifications including controls (child gender, child age, mother’s education, and an index of household assets), having an older sister as opposed to an older brother is associated with a 0.130 standard deviation increase in vocabulary (p-value 0.042) and a 0.151 standard deviation increase in fine motor skills (p-value 0.063).

In Figures 3 and 4, we present quantile regressions of the impact of older sisters on vocabulary and fine motor skills. In both cases, the largest point estimates occur near

\(^5\)In OLS specifications including controls for child gender, age (fixed effects for child age in months), mother’s education, and an index of household wealth, the coefficient on maternal education (years of schooling) is 0.031 (p-value 0.042).
the bottom of the distribution. However, impacts on the quantiles of fine motor skills are precise zeros in the top half of the distribution, while estimated impacts on quantiles below the median are substantially larger and often statistically significant. Thus, having an older sister appears to improve fine motor skills, but only below the median. In contrast, estimated impacts on vocabulary skills are consistently small and positive, though they are rarely statistically significant above the 20th percentile.

The last child development outcome that we consider is stunting. Children are considered stunted if their height-for-age z-score is below $-2$. OLS estimates of the impact of older sisters suggest that rates of stunting are between 4.7 percentage points (with controls) and 5.9 percentage points (without controls) lower in households with an older girl (p-values 0.069 and 0.015, respectively). In Figure 5, we plot the results of quantile regressions of height-for-age z-scores on the indicator for having an older sister. Having a sister has a large, positive impact on the lowest quantiles of height-for-age, but no discernible effect above above about the 20th percentile. Thus, impacts on height are similar to those observed on fine motor skills: for both measures of physical development, we see effects at the bottom of the distribution, but (relatively) precise zeros above the median.

4.3 The Impact of Big Sisters on Investments in Young Children

So far, we have focused on estimating the treatment effect of having an older sister rather than an older brother. We have shown that having an older sister leads to substantial improvements in child development outcomes for younger siblings. As discussed in Section 2, there are two main reasons that younger siblings might benefit from having an older sister. One possibility is that older sisters invest more in their young siblings, or they may be more effective at improving children’s younger siblings’ human capital conditional on a fixed level of investment. Alternatively, parents may invest more in young children when their older child is a girl; this could occur if parents believe that the return to investing in older girls’ human capital is relatively low.

We test whether parents are the main channel of impact in two ways. First, we estimate
the impact of having an older sister on three types of household investment: preventative health investments (e.g. vaccinations and vitamin supplements), ownership of (manufactured) toys, and direct cognitive stimulation (through activities like reading and physical play). Both health investments and toys can only be made by parents (and typically entail either monetary or opportunity costs), while cognitive stimulation can be done by any older household member at zero (monetary) cost. To further understand who invests in young children, we decompose impacts on cognitive stimulation into stimulation by specific household members (e.g. parents vs. siblings). This allows us to explicitly test whether parents are the main mediator of causal impacts.

Estimates of the impact of having an older daughter on households’ investment in young children are reported in Panel C of Table 2. Having an older sister does not have a statistically significant impact on either the number of preventative health investments a household makes in a young child or the likelihood that a child plays with store-bought toys. Hence, we do not find any evidence that parents invest more in young children when their older child is female. However, we find large and statistically significant impacts of older sisters on the level of early childhood stimulation a child experiences. Having an older sister increases the number of different stimulating activities (out of 12) over the three days prior to the survey by between 0.637 (without controls, p-value 0.006) and 0.703 (with controls, p-value 0.002). Among households where the older child is male, the mean number of stimulating activities is 5.147; hence, the estimated treatment effect of having an older sister represents more than a ten percentage increase in early childhood stimulation.

In Table 3, we estimate the impact of big sisters on the level of early childhood stimulation by different household members. Having an older sister does not increase or decrease the level of parental investment in younger children, allowing us to rule out several of the models discussed in Section 2. We also do not observe any statistically significant impacts of older sisters on early childhood stimulation by grandparents or other adults. Instead, we see clear evidence that the overall impact on stimulation is driven by changes in the level of stimulation done by siblings. Having an older sister increases the amount of stimulation
done by sisters and decreases the amount done by brothers, but the positive impact on stimulation by sisters is larger — leading to a positive impact on the overall level of sibling stimulation.\textsuperscript{6}

5 Conclusion

Older sisters have a positive and significant impact on their younger siblings development. Our results are not driven by differences in parental investments, but seem to result from the greater cognitive stimulation by sisters. Our results highlight the critical importance of older children (both sisters and brothers) in child rearing in developing country contexts. In our sample, siblings do more cognitive stimulation than any other household member — but their role is typically ignored in models of household investments in children and policy discussions about early childhood. Siblings, particularly sisters, play an important role in shaping the developmental trajectories of young children.

\textsuperscript{6}Since our measure also captures stimulation by adult siblings, the level of stimulation by older sisters is not zero in households where the older child is male.
References


Figure 1: Kernel Density Estimates of Early Childhood Development Indices

Figure 2: Quantile Regressions of the Impact of Sisters on Early Childhood Development
Figure 3: Quantile Regressions of the Impact of Sisters on Vocabulary

Figure 4: Quantile Regressions of the Impact of Sisters on Fine Motor Skills
Figure 5: Quantile Regressions of the Impact of Sisters on Height-for-Age
<table>
<thead>
<tr>
<th>Older sibling is a...</th>
<th>Sister</th>
<th></th>
<th>Brother</th>
<th></th>
<th>Difference</th>
<th></th>
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<tbody>
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<td></td>
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<td>S.D.</td>
<td>Mean</td>
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<td>9.51</td>
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<td>0.84</td>
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<td>0.06</td>
<td>0.60</td>
</tr>
<tr>
<td>Mother is Luo</td>
<td>0.95</td>
<td>0.21</td>
<td>0.95</td>
<td>0.22</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Mother’s education in years</td>
<td>7.88</td>
<td>2.39</td>
<td>8.02</td>
<td>2.42</td>
<td>-0.15</td>
<td>0.21</td>
</tr>
<tr>
<td>Father unknown or deceased</td>
<td>0.24</td>
<td>0.43</td>
<td>0.19</td>
<td>0.39</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Father’s age</td>
<td>39.41</td>
<td>9.43</td>
<td>38.37</td>
<td>9.22</td>
<td>1.04</td>
<td>0.87</td>
</tr>
<tr>
<td>Father is Luo</td>
<td>0.99</td>
<td>0.10</td>
<td>0.98</td>
<td>0.14</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Father’s education in years</td>
<td>8.67</td>
<td>2.76</td>
<td>8.89</td>
<td>2.59</td>
<td>-0.23</td>
<td>0.25</td>
</tr>
<tr>
<td>Number of young children</td>
<td>0.38</td>
<td>0.48</td>
<td>0.47</td>
<td>0.50</td>
<td>-0.09</td>
<td>0.05</td>
</tr>
<tr>
<td>Has cement floor</td>
<td>0.15</td>
<td>0.36</td>
<td>0.16</td>
<td>0.37</td>
<td>-0.01</td>
<td>0.03</td>
</tr>
<tr>
<td>Has iron roof</td>
<td>0.98</td>
<td>0.13</td>
<td>0.99</td>
<td>0.12</td>
<td>-0.00</td>
<td>0.01</td>
</tr>
<tr>
<td>Has latrine or toilet</td>
<td>0.81</td>
<td>0.40</td>
<td>0.78</td>
<td>0.42</td>
<td>0.03</td>
<td>0.04</td>
</tr>
<tr>
<td>Has solar power</td>
<td>0.39</td>
<td>0.49</td>
<td>0.44</td>
<td>0.50</td>
<td>-0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Observations</td>
<td>352</td>
<td></td>
<td>347</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Statistical significance: ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.
Table 2: Impacts of Big Sisters on Early Childhood Development

<table>
<thead>
<tr>
<th>Panel A. Summary Measures of Younger Siblings’ Development</th>
<th>No Controls</th>
<th>W/ Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Coef. S.E. Coef. S.E.</td>
<td>Mean Coef. S.E. Coef. S.E.</td>
</tr>
<tr>
<td>Child development index (z-score)</td>
<td>-0.022 0.129** 0.061 0.141** 0.062</td>
<td></td>
</tr>
<tr>
<td>Child is stunted</td>
<td>0.128 -0.059** 0.024 -0.047* 0.026</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B. Components of Child Development Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Child vocabulary (z-score)</td>
</tr>
<tr>
<td>Fine motor skills (z-score)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel C. Household Investments in Young Children</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Preventative health investments (out of 8)</td>
</tr>
<tr>
<td>Child plays with store-bought toys</td>
</tr>
<tr>
<td>Early childhood stimulation index (out of 12)</td>
</tr>
</tbody>
</table>

OLS coefficients reported. Robust standard errors clustered at the household level. The mean indicates the average variable of each outcome variable among households with a single male child between the ages of 7 and 14; the OLS coefficient estimates denote the treatment effect of having a older sister rather than an older brother (in the eligible age range). The specification with controls includes child age (fixed effects for age in months), child gender, mother’s education, household size, and an index of household assets. Statistical significance: ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.
Table 3: The Impacts of Big Sisters on Stimulation

<table>
<thead>
<tr>
<th></th>
<th>No Controls</th>
<th>W/ Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Coef.</td>
</tr>
<tr>
<td>Child stimulation index (out of 12)</td>
<td>5.147</td>
<td>0.637</td>
</tr>
<tr>
<td>Stimulation by parents</td>
<td>1.968</td>
<td>-0.102</td>
</tr>
<tr>
<td>Stimulation by mother</td>
<td>1.438</td>
<td>-0.012</td>
</tr>
<tr>
<td>Stimulation by father</td>
<td>0.599</td>
<td>-0.099</td>
</tr>
<tr>
<td>Stimulation by siblings</td>
<td>2.346</td>
<td>0.745</td>
</tr>
<tr>
<td>Stimulation by older brothers</td>
<td>1.850</td>
<td>-1.248</td>
</tr>
<tr>
<td>Stimulation by older sisters</td>
<td>0.712</td>
<td>2.027</td>
</tr>
<tr>
<td>Stimulation by grandmother</td>
<td>0.205</td>
<td>-0.011</td>
</tr>
<tr>
<td>Stimulation by grandfather</td>
<td>0.055</td>
<td>-0.032</td>
</tr>
<tr>
<td>Stimulation by others</td>
<td>0.916</td>
<td>0.069</td>
</tr>
</tbody>
</table>

OLS coefficients reported. Robust standard errors clustered at the household level. The mean indicates the average variable of each outcome variable among households with a single male child between the ages of 7 and 14; the OLS coefficient estimates denote the treatment effect of having a older sister rather than an older brother (in the eligible age range). The specification with controls includes child age (fixed effects for age in months), child gender, mother’s education, household size, and an index of household assets. Statistical significance: 

* indicates significance at the 10 percent level.

** indicates significance at the 5 percent level.

*** indicates significance at the 1 percent level.
6 Online Appendix: not for print publication

6.1 Mathematical Appendix

6.1.1 Proof of Proposition 1.

The proof proceeds in 3 steps. First, we prove through contradiction that an increase in $\delta$ always leads to an increase in $I_y^*$. We then show that the increase in $\delta$ must also lead to an increase in $p_o^*$ and $L_p^*$ and a decrease in $p_y^*$.

Step 1. An increase in $\delta$ leads to an increase in $I_y^*$.

Assume not: assume an increase in $\delta$ leads to either a decrease or no change in $I_y^* = p_y^* + \delta o_y^*$.

First, consider the possibility that an increase in $\delta$ leads to a decrease in $I_y^*$. By Equation 6, this implies an increase in both $y'(1 - p_o^* - p_y^*)$ and $\lambda_i g'(p_o^*)$. The latter implies a decrease in $p_o^*$ since $g(\cdot)$ is strictly concave. By a similar argument, the former implies an increase in $p_o^* + p_y^*$, since we’ve already shown that $p_o^*$ must have decrease, $p_y^*$ must increase. So, if an increase in $\delta$ leads to a decrease in $\delta o_y^* + p_y^*$, it implies an increase in $p_y^*$ — so the decrease in $\delta o_y^* + p_y^*$ must come from an increase in $o_y^*$.

An increase in $\delta$ must also lead to either an increase in $f'(1 - o_y^*)$ or a decrease in $h'(\delta o_y^* + p_y^*)$ (or both) if Equation 7 is to hold. Since we started from the assumption that $\delta o_y^* + p_y^*$ is declining, $h'(\delta o_y^* + p_y^*)$ must increase. Hence, Equation 7 can only hold if $f'(1 - o_y^*)$ increases. However, we have already shown that $o_y^*$ must decrease, so $1 - o_y^*$ and $f(1 - o_y^*)$ must increase — leading to a decrease in $f'(1 - o_y^*)$. Thus, the assumption that an increase in $\delta$ leads to a decrease in $I_y^*$ leads to a contradiction.

Next, consider the possibility that an increase in $\delta$ leads to no change in $I_y$. This means that there is no change in $h'(\delta o_y^* + p_y^*)$. There is consequently no change in either $p_o^*$ or $p_y^*$ (by Equation 6). Since $p_y^*$, $o_y^*$ must decrease to offset the increase in $\delta$ (keeping $I_y$ constant). This implies an increase in $f'(1 - o_y^*)$. However, Equation 7 requires an increase in $f'(1 - o_y^*)$ to offset the increase in $\delta$ — since $h'(\delta o_y^* + p_y^*)$ and $\lambda$ do not change. So $f'(1 - o_y^*)$ must increase and decrease simultaneously — a contradiction.

Step 2. An increase in $I_y^*$ (with no change in $\lambda_i$) leads to an increase in $p_o^*$.

This follows directly from Equation 6 since $g(\cdot)$ and $h(\cdot)$ are concave.

Step 3. An increase in $I_y^*$ and $p_o^*$ implies an increase in $L_p^*$ and a decrease in $p_y^*$.

Since $h(\cdot)$ and $y(\cdot)$ are both strictly concave, the decrease in $h'(\delta o_y^* + p_y^*)$ (resulting from the increase in $I_y^*$) means that $y'(1 - p_o^* - p_y^*)$ must also decrease if Equation 6 is to hold. Hence, $L_p^* = 1 - (p_o^* + p_y^*)$ must increase, and $p_o^* + p_y^*$ must decrease. However, we have already shown that an increase in $I_y^*$ leads to an increase in $p_o^*$. So, an increase in $\delta$ must therefore lead to a decrease in $p_y^*$.

□
6.1.2 Proof of Proposition 2.

The proof proceeds in $K$ steps. First, we prove through contradiction that a decrease in $\lambda$ always leads to a decrease in $p_o^*$. We then show that the increase in $\delta$ must therefore lead to an increase in $E_o^*$ and an increase in $o_y^*$. Finally (?), we show that the increase in $\lambda$ must therefore lead to an increase in $I_y^*$ and $L_p^*$.

Step 1. A decrease in $\lambda$ leads to a decrease in $p_o^*$.

Assume not: assume a decrease in $\lambda$ leads to either an increase or no change in $p_o^*$.

Since $\lambda = y'(1 - p_o^* - p_y^*)/g'(p_o^*)$ (Equation 6), an decrease in $\lambda$ means that either $y'(1 - p_o^* - p_y^*)$ must decrease or $g'(p_o^*)$ must increase. Because $g(\cdot)$ is concave, $g'(p_o^*)$ can only increase if $p_o^*$ decreases. So, for $\lambda$ to decrease without a decrease in $p_o^*$, $y'(1 - p_o^* - p_y^*)$ must decrease — this to happen without a decrease in $p_o^*$, $p_y^*$ must decrease.

By Equation 6, $\lambda = h_y'(\delta p_y^* + p_y^*)/g'(p_o^*)$. So, if $\lambda$ decreases and $p_o^*$ does not, $h_y'(\delta p_y^* + p_y^*)$ must decrease. Since $h_y'(\cdot)$ is concave, this implies an increase in either $o_y^*$ or $p_y^*$. Above, we demonstrated that $p_y^*$ must decrease (if $\lambda$ decreases and $p_o^*$ does not), so $o_y^*$ must increase.

Combining Equation 6 and Equation 7, we see that

$$\frac{g'(p_o^*)}{f'(1 - o_y^*)} = \frac{1}{\delta}. \tag{12}$$

Since $o_y^*$ must increase and $\delta$ does not change, we see that $p_o^*$ must increase — though we have assumed that it does not. Thus, starting from the assumption that $p_o^*$ does not decline leads to a contradiction. Hence, a decrease in $\lambda$ implies a decrease in $p_o^*$.

Step 2. The decrease in $p_o^*$ implies a decrease in $E_o^*$ and an increase in $o_y^*$.

This follows directly from Equation 12 and the definition of $E_o^*$.

Step 3. The decrease in $p_o^*$ implies an increase in $I_y^*$ and $L_p^*$.

We proceed by contradiction. We have already shown that $o_y^*$ must increase. As a consequence, if we assume that $I_y^*$ does not increase, then $p_y^*$ must decrease. Since we have already shown that $p_o^*$ must decrease, this means that $1 - (p_o^* + p_y^*)$ must increase, and (by concavity) $y'(1 - p_o^* - p_y^*)$ must decrease. Note, however, that if $I_y^*$ does not increase, then $h_y'(\delta o_y^* + p_y^*)$ cannot decrease and (as a result) Equation 6 cannot hold. This is a contradiction. So, $I_y^*$ must increase, and (by Equation 6) $L_p^*$ must increase as well.