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ABSTRACT

Birth Order, Fertility, and Child Height in India and Africa*

The poor state of child health in India has generated a number of puzzles that have received attention in the literature. A recent focus on birth order has produced contradictory results. Coffey and Spears (2019) document an early-life survival advantage in India accruing to later birth orders, which they interpret as the result of a pattern of improving maternal nutrition over mothers' childbearing careers. In apparent contrast, Jayachandran and Pande (2017) show, using the same set of demographic surveys, a *disadvantage* in child height for later birth orders in India relative to Africa's birth order gradient. They interpret this pattern as discrimination against later birth-order children in India. This paper resolves the apparent contradiction, showing how differing correlations between sibsize (a child's number of siblings) and household wellbeing can account for the empirical findings of both studies: A mother having higher fertility, rather than lower, implies more socioeconomic disadvantage within India than within Africa. Accounting for sibsize reverses the apparent Indian laterborn disadvantage in child height, reversing the interpretation of Jayachandran and Pande. In short, a child's sibsize (or, equivalently, its mother's fertility) is an omitted variable in Jayachandran and Pande's analysis of birth order effects. Resolving these puzzles is critical for human development policy to combat the enduring challenges of disproportionately high rates of stunting and neonatal death in India, where one-fifth of global births occur.

JEL Classification: O15, I15

Keywords: child height, birth order, India, DHS, high-dimensional fixed effects

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Children in India are shorter, on average, than children in sub-Saharan Africa (SSA), despite the fact that children in SSA are poorer. This puzzle has been named the "Asian Enigma" (Ramalingaswami et al., 1996) and has received considerable attention (e.g. Deaton, 2013). Recently, Jayachandran and Pande's (2017) article "Why Are Indian Children So Short?" — hereafter JP — has proposed birth-order effects within India as an explanation. Its main result reports that child height is more negatively associated with birth order in India than in SSA. JP interprets the correlation between birth order and height as evidence for an effect of birth order, such that discrimination against later-born children causes India's child height deficit.

This result is in puzzling contrast with another recent study in the literature. Coffey and Spears (2019, hereafter CS), using the same survey data, have recently shown that later-born children in India have an early-life survival *advantage*. Figure 1 introduces the puzzle. Panel (a) plots the coefficients reported by JP in an interaction between birth order and India, predicting child height-for-age z-scores. The negative coefficients and slope suggest a later-born disadvantage in India. Panel (b) plots the coefficients on a similar regression reported by CS: because here the dependent variable is mortality, the negative coefficients and slope indicate a later-born advantage. The other two panels deepen the puzzle. Panel (c) uses sample means to demonstrate the apparent clarity and simplicity of JP's result: on average, later birth order predicts being shorter in India but not in SSA. Yet panel (d) emphasizes that the JP and CS results should cohere: at the population level, child height and early-life mortality are well-known to be correlated (Bozzoli et al., 2009; Coffey, 2015a).

In this paper, we resolve this puzzle. We show that JP's interpretation does not adequately account for the correlation between birth order and *sibsize* (which is the number of siblings a child has). Prior research demonstrates the necessity of holding sibsize constant when identifying birth-order effects (Behrman and Taubman, 1986) because there is a mechanical relationship in which children of later birth order must come from larger families. To see this, suppose for example that larger families were poorer and had children in worse health, but that within a family all children were exactly equally healthy. A regression of health on only birth order would find a negative effect of being later-born on health (i.e., the regression would suggest an advantage for earlier-birth-order children). But this finding would be a spurious artifact of the bias created by the key omitted variable of sibsize.

Holding sibsize constant is especially important in this case because the two regions that JP compares — India and SSA — are at different points in their fertility transitions. Indian mothers with more births are shorter, on average, and come from poorer households than Indian mothers with fewer births; but sub-Saharan African mothers with more births are slightly healthier and richer than sub-Saharan African mothers with fewer births (Vogl, 2015). Figure 2 documents that this omitted variable bias threat is indeed true of the children whose heights JP study. Using the same survey data as JP and CS, Figure 2 documents that higher fertility predicts greater disadvantage by more in India than in SSA.[1] Panel (a) is particularly noteworthy, because it plots the average height-for-age z-score of all of a mother's measured children. It closely resembles Panel (c) of Figure 1 but has a different horizontal axis: sibsize, not birth order.

Because of the design of the survey that JP studies, in which height is only measured for a non-random subsample of children, some empirical strategies from the birth-order literature that otherwise adequately separate birth order and sibsize are poorly suited to this case. As a result, JP's inference amounts to making across-family comparisons (large versus small families) but interpreting them as within-family effects (later versus earlier-born children). In contrast with the height data that JP study, the mortality that CS study is not truncated by child age.

Figure 3 shows that there is no later-born disadvantage in India when comparing children with the same number of siblings. Instead, in India, children *with more siblings* are shorter than children *with fewer siblings* at the time their height is measured. This is not the case in SSA, where child height is unrelated to the number of siblings a child has. Panels (a) and (b) report

[1] Because every variable in Figure 2 is at the mother or household level, birth order is not a potential confounder of these comparisons.

patterns of neonatal mortality, reprinted from CS; panels (c) and (d) summarize child height, computed here using the same data as JP. In particular, Panels (c) and (d) of Figure 3 show that, within India, higher-sibsize children are shorter than lower-sibsize children, on average, but that, conditional on having the same number of siblings, later-born children are as tall or taller than earlier-born children. This is the opposite of the birth-order pattern that JP presents as its main result. Therefore, any apparent evidence for discrimination by birth order influencing child height is eliminated by the accounting for sibsize that the data permit. So, there is no conflict between what is true of early-life mortality and what is true of child height.

Figure 3 suggests that the DHS data used by both studies do not provide evidence of a negative effect of birth order on height in India. The rest of this paper reports details that support this conclusion. Section 1 presents our empirical strategy and that of JP in the context of the econometric literature on birth order. As we show there, Demographic and Health Survey (DHS) height data — unlike complete census data or administrative records — are not well-suited to making within-family comparisons controlling for sibsize. Because the DHS measures the heights of only those children who are under five years old, almost three-fourths of the children in the data with measured height are the last-born child to their mother at the time when height is measured, and over 97% are last born or next-to-last born. One implication is that, for example, a child with a birth order of four (the mean birth order in SSA) cannot be compared to his or her first-born *sibling* using these data. Another implication is that the correlation between sibsize and birth order in JP's sample of children with measured height is 0.98; this correlation would make sibsize an important omitted variable if it is also correlated with height, which we show is the case. By comparison, the correlation is 0.63 among all births (of any age, with or without height data) recorded in the same set of DHS surveys.

Section 2 presents our main result: we elaborate on Figure 3 by accounting for sibsize in JP's regression framework. The addition of regression controls for sibsize interacted with India reverses the interaction of interest in JP's main result. Acknowledging the omitted variable problem in which birth order stands in for sibsize yields a variety of further implications for other specifications in JP's analysis, which we consider in the remainder of the paper.

JP interprets its result as evidence for an advantage for first-born boys; section 3 considers this interpretation. Although there is indeed much evidence of social inequality in India, including many forms of sex discrimination, JP's interpretation here is limited by the same omitted variable bias and data structure that affect the main results. Further, because few measured children have a first-born sibling whose height was also measured, most of the data cannot speak to a first-born intra-household height advantage. In section 3.1, we show that whether the sample is restricted only to boys or restricted only to girls, India shows no later-born disadvantage once sibsize is accounted for. Testing for an effect of first-borns to the extent possible in the data (meaning, within sibsizes of two), we show that there is no evidence for a first-born or a first-born boy advantage in India. Section 3.2 considers the implications of the fact that 97% of JP's height sample is last-born or next-to-last born at the time of the survey.

We then explain how, because of the age-censoring of the DHS height data, attempting to control for unobserved aspects of family well-being with mother fixed effects yields a misspecified result. Section 4 considers the use of mother-fixed-effects as a solution to the omitted variable problem.[2] That section builds upon Banerjee and Duflo (2003), who demonstrate the potential for fixed effects to mislead in a case where a linear fixed-effects model overlooks important heterogeneity in the parameter of interest. The issue is broadly relevant as mother-fixed-effects are a strategy that is widely employed in the development and health economics literatures. An

[2]Although JP does not note the empirical pattern in Figure 2, JP does discuss the conceptual possibility that sibsize is an omitted variable in its results. Moreover, although the paper does not account for sibsize in its main results, it includes two robustness checks intended to address it in other samples. The main strategy that JP uses is mother fixed effects; the second is to show results for a sub-sample of children whose mothers JP interprets to have completed fertility. However, even these strategies remain limited by the structure of the available data. We show that both are fragile, ultimately because they are misspecified for studying height in the DHS: the sign and magnitude of the coefficients of interest are highly sensitive to specification choices in both robustness checks. The main text focuses on mother fixed effects because this strategy is widely used in applied micro. Results in the supplementary appendix discuss JP's other robustness check: a restriction of the sample to mothers that JP interprets to have completed fertility. This result is sensitive to controls or to JP's assignment of a birth order to multiple births, such as twins.

important difference from the familiar implementation of fixed effects in other data is that in the DHS height data that JP use there is severe, non-random data censoring that substantively changes the interpretation of fixed effects. In particular, the age-based cutoff for measuring height in the DHS makes the sub-set of observations with multiple child heights per mother unrepresentative of all children, and unrepresentative of children with measured height. In other words, fixed effects are misspecified because of non-random censoring of the subset with multiple observations per mother. Therefore, our paper advances an active econometric literature that is highlighting the potential for fixed effects to mislead in cases of parameter heterogeneity (Gibbons et al., 2014; Imai and Kim, 2014) because we document an actual occurrence of such unintuitive consequences in a high-profile, practically important case.

Finally, section 5 reconciles the findings of JP and CS. CS study mortality, which is recorded for all children ever born by the time of the survey. In other words, studying mortality allows CS to use the full birth history, as opposed to the truncated sample studied by JP. In this section, we analyze early-life mortality in the way that JP study height, and impose the same non-random censoring on the mortality data by including only children born in the five years immediately before each survey. Thus, although mortality data are available for the full birth history, we analyze mortality *as though* it were restricted in the way that height data are. We find that when we inappropriately censor the mortality data, we find the opposite pattern to what CS find in the full mortality dataset: with mortality age-censored in the way height is and using JP's empirical strategy (i.e., not controlling for sibsize), we find the same apparent later-born disadvantage that JP find in the height data.

A discussion in section 6 considers what can be learned about the effect of birth order on child height in these data. Some of our findings suggest that there may be a *positive* effect of later birth order on child height in India. If true, this would be consistent with the conclusions of CS: young women in India begin their childbearing careers undernourished, and gain weight as they get older and have more children (Coffey, 2015b). However, we conclude that these data do not allow researchers to identify an effect of birth order on child height with confidence. Because use of the DHS height data and of mother fixed effects are both common throughout development economics, these results are of broad methodological relevance.

1 Empirical strategy: Identifying birth-order effects

The identification of birth-order effects has received sustained attention in part because it speaks to core questions in economic demography about intrahousehold allocation and the lasting consequences of childhood. As a result, an econometric literature has developed standard strategies. Identifying birth-order effects is challenging because birth order is inherently correlated with other variables that are correlated with outcomes, including age, sibsize, mothers' fertility, mothers' age at birth, and birth spacing. For example, an earlier-birth-order child must be older and born to a younger mother than a later-birth-order sibling; similarly, all late-birth-order children come from large sibsizes, but only some early-birth-order children do.

These issues have been well-studied. As Blake (1989) wrote to introduce an "outline of confounding factors in the analysis of birth order:" … "most findings appear to involve highly selective reporting of what are, in reality, sibsize, period, parental background, child-spacing, and other selection effects for which controls have not been instituted" (p. 300). Among these, the importance of flexibly controlling for sibsize has received special attention in the economics literature because higher-fertility mothers are different, on average, than lower fertility mothers (Black et al., 2005). In an early study of birth-order effects in the economics literature, Behrman and Taubman (1986) note this problem explicitly, citing Ernst and Angst (1983) and observing that "many studies … fail to control for family size and family background. Later birth orders, for example, are only observed for larger families that have different child quantity/child quality trade-offs. If so, then birth-order effects from interfamilial data may be reflecting only differential child quality/quantity shadow prices across families and not within-family birth-order effects" (p.

S131). Other econometric investigations of birth order that present results separately by sibsize include Price (2008); Hatton and Martin (2009); Buckles and Kolka (2014); De Haan et al. (2014); and Lehmann et al. (2016).

1.1 Data: Demographic and Health Surveys

We follow JP's use of Demographic and Health Surveys (DHS). In particular, we replicate JP's use of the 2005-6 Indian DHS[3] (which was the most recent at the time of their paper) and the same set of 27 recent survey rounds from countries in SSA.

DHS are nationally representative of women of childbearing age and provide data on fertility, health, and nutrition (including anthropometric measurements). As a result of the DHS' focus on fertility, each survey round includes a complete, retrospective birth history in which adult women are asked a standard set of questions about each of their children ever born. However, height is measured for only 17% of children whose births are recorded in the birth histories of the DHS surveys that JP studies. This is primarily because of the design of the DHS: only the youngest children are intended to be measured. Although the age cutoff for measuring child anthropometry differs by DHS round, in the set of DHSs used by JP (and that we use here) children are only eligible to have their heights measured if they are under five years old.

In this paper, we refer to four samples from the DHS birth histories that JP uses:

- **Full birth history**: $n = 987,447$. These are all children ever born alive (prior to the survey) to the mothers surveyed by the DHS. 83% of these do not have measured height. This is the sample that CS uses. For each observation, early-life mortality is observed.

- **Main height sample**: $n = 166,153$.[4] These are children under 60 months old who are

[3] JP includes a robustness check using the India Human Development Survey; we use these data in Figure A.7.

[4] JP reports a 1% larger main sample, with 168,108 births. Our understanding is that the principal reason that our main height sample does not match JP's sample exactly is that, to match the birth-order literature, we drop multiple births (such as twins or triplets) throughout our analysis. This follows Black et al. (2005), who explain: "We dropped twins because of the ambiguities involved in defining birth order for twins" (p. 672). JP recodes these

alive at the time of the survey and who have their heights measured.

- **Mother-fixed-effects subsample**: $n = 80,785$. These are children under 60 months old who are alive at the time of the survey, who have their heights measured, and who have at least one sibling who also meets these criteria. JP uses these observations in a robustness check that we discuss in detail in Supplementary Appendix B.

- **"Completed fertility" subsample**: $n = 67,194$. These are children in the main height sample whose mothers are sterilized or infecund, or whose mothers report wanting no more children.[5] Because high fertility is more common in SSA than in India, over two-thirds of the Indian main height sample is in the "completed fertility" subsample, but less than one-third of the SSA observations are. JP uses these observations in a robustness check that we discuss in detail in Supplementary Appendix C.

Table 1 describes the make-up of the main height sample by birth order and children's eligibility for the mother-fixed-effects subsample. The use of age-restricted data is an important contrast with studies of birth order such as Black et al. (2005), which use census-like administrative data on all of the siblings born to a particular mother. The correlation between birth order and sibsize is 0.98 in JP's age-restricted main height sample, compared with 0.63 in the full birth history of children ever born in the same DHS rounds. In the main height sample, 72% of measured children are the last born to their mother and 97% are the last or next-to-last born at the time of the survey, compared with 28% and 50% in the full birth history.

children to share the same birth order; as a result, our final sample is slightly smaller than JP's. In Table A.17, we show that one of JP's robustness checks is sensitive to the fact that multiple births are included in its sample. JP additionally restricts the sample based on an age variable constructed for JP's analysis, that differs from the age variable included in the DHS; we use the age-in-months variable provided by the DHS for transparency. Despite this small difference in the sample, the analyses for which we show pure replication results are numerically very similar to JP's, and are almost identical in Table A.18, where we include multiple births as a robustness check.

[5] We follow JP in calling this the "completed fertility" subsample, although as we note in Supplementary Appendix C that many of the women who report wanting no more children are not using modern contraception. Table A.17, which uses the completed-fertility subsample, reports a slightly larger sample than the sample size listed here because it demonstrates that JP's robustness check on this sample is sensitive to the inclusion of multiple births (twins, triplets). See footnote [4] on page 7.

1.2 Regression specification

JP estimates the following regression specification:

$$\begin{aligned} h_{imc} &= \alpha_1 \textbf{\textit{India}}_c + \alpha_2 \textbf{\textit{India}}_c \times \textbf{\textit{second-born}}_{imc} + \alpha_3 \textbf{\textit{India}}_c \times \textbf{\textit{third-or-later-born}}_{imc} \\ &\quad + \beta_1 + \beta_2 \textbf{\textit{second-born}}_{imc} + \beta_3 \textbf{\textit{third-or-later-born}}_{imc} + \gamma X_{imc} + \varepsilon_{imc}, \end{aligned} \tag{1.1}$$

where i indexes children, m indexes mothers, c indexes the country, and $\textbf{\textit{India}}_c$ is an indicator that is 1 for Indian observations and 0 for SSA. The dependent variable h is the child's height-for-age z-score (HAZ) based on WHO norms (World Health Organization and others, 2006). The coefficients of interest are α_2 and α_3, which are the difference-in-difference estimators of how the average gaps between first-borns and later-borns differ in the Indian sample, relative to these gaps in the SSA sample. β_2 and β_3 are average HAZ differences in SSA relative to first-borns, whose mean height is the constant β_1.

Note that equation 1.1 considers differences in height by birth order relative to first-born children. Because the DHS only measured the heights of children under five, almost 40% of the children in the main height sample are third-born or later (that is, third-born, fourth-born, etc.). Equation 1.1 therefore disregards substantial variation in birth order at birth orders greater than three. Section 3.2 investigates an alternative specification that considers differences between children who are next-to-last-born and last-born when measured.

In some other birth order studies, age is held constant in the dependent variable, so the time period of interest differs across siblings: for example, Black et al. (2005) study educational attainment by age 25, CS study mortality in the first month of life, and Buckles and Kolka (2014) study inputs at specific gestational and early-life ages. The DHS, in contrast, measures height at one point in time per family, so children are measured at different ages. There is a well-studied relationship between height-for-age z-scores and age in children under two in developing countries (Victora et al., 2010): mean height-for-age z-scores fall over the first two years of life, and flatten (as a function of age) at age two. For a visual summary of this age pattern, see Supplementary Appendix Figure A.1. So, we, JP, and most studies of child HAZ control flexibly for age in months. Because later-born children are younger, they appear taller if age is not controlled (see Figure A.3; this misspecified result would be the opposite of JP's interpretation). X_{imc} is therefore a vector of control variables that includes, at least, 59 age-in-months indicators.

In our main result, we investigate the consequences of adding controls for sibsize × India indicators. We estimate the following specification:

$$\begin{aligned} h_{imc} \quad = \quad & \alpha_1 \mathit{India}_c + \alpha_2 \mathit{India}_c \times \mathit{second\text{-}born}_{imc} + \alpha_3 \mathit{India}_c \times \mathit{third\text{-}or\text{-}later\text{-}born}_{imc} \\ & + \beta_1 + \beta_2 \mathit{second\text{-}born}_{imc} + \beta_3 \mathit{third\text{-}or\text{-}later\text{-}born}_{imc} \\ & + \delta_2^I \mathit{India}_c \times \mathit{sibsize\text{-}of\text{-}2}_{imc} + \delta_3^I \mathit{India}_c \times \mathit{sibsize\text{-}of\text{-}3}_{imc} + \ldots \\ & + \delta_2 \mathit{sibsize\text{-}of\text{-}2}_{imc} + \delta_3 \mathit{sibsize\text{-}of\text{-}3}_{imc} + \ldots + \gamma X_{imc} + \varepsilon_{imc}. \end{aligned} \tag{1.2}$$

Equation 1.2 differs from 1.1 only by the inclusion of sibsize at the time height is measured[6] and sibsize × India indicators, which include all sibsizes in the data (represented in the equation as the ellipsis). Because of the high correlation between sibsize and birth order in the main height sample, these omitted controls are important in principle, and we show, critical in practice. The main results of CS are estimates of equation 1.2, not equation 1.1, using the full birth history.[7] Our estimations of equation 1.2 are the topic of section 2. JP does not present estimates of equation 1.2 for the main height sample.

For all of our analyses, annotated Stata do files and log files are available at `https://liberalarts.utexas.edu/prc/directory/faculty/spearsde`.

[6]Sometimes we refer to this variable as "sibsize" and sometimes as "children ever born;" in so doing, we follow the DHS's "children ever born" terminology. Some women will have more births after the time of the survey and of the relevant height measurement. So, in our mortality results (see Table 5), we present robustness checks that exclude children born to mothers who have given birth in the past five years. Note that this common strategy in the literature is unavailable when studying height, because the only children measured are those born in the last five years; this is a further reason why identifying effects of birth order on height with these data is unreliable in ways that identifying effects of birth order on mortality is not.

[7]Unlike JP and therefore unlike equations 1.1 and 1.2, CS does not topcode birth order at "third-or-later." Additionally, CS studies age-specific mortality rates, and therefore cannot control for child age.

2 Sibsize, fertility, and height in India and SSA

This section presents the main result of our investigation: once sibsize is controlled, later-born children in India are not shorter relative to earlier-born children by more than later-born children in SSA are shorter relative to earlier-born children. Adequately controlling for sibsize prevents birth order comparisons from being confounded by the mechanical correlation between birth order and sibsize. Sibsize is an important control in the birth-order literature in general, and it is particularly important in this case for two reasons. First, as we have discussed, because the DHS only measures the height of children under five, sibsize and birth order are more highly correlated among births with measured height than among all births. Second, as section 2.1 discusses, because India and SSA are at different points in the fertility transition, higher sibsize predicts worse outcomes in India, but slightly better outcomes in SSA. Therefore, the interaction between sibsize and India is an important omitted variable.

2.1 Fertility in India and sub-Saharan Africa

On average, children of different birth orders come from different sibsizes, that is, from mothers with different numbers of children. This fact would be a threat to identification of an effect of birth order only if sibsize were also correlated with health outcomes, such as height. A substantial literature in demography indicates that this is the case: mothers' total fertility is correlated with child outcomes in a qualitatively different way in India than it is in SSA.

Average fertility is lower in India (Das Gupta and Mari Bhat, 1997; Drèze and Murthi, 2001) than in SSA (Caldwell and Caldwell, 1987; Kohler and Behrman, 2014). For the 2005-2010 interval — which is the period that includes the Indian DHS that JP uses — the UN World Population Prospects estimates that SSA's total fertility rate was 5.4 live births per woman, compared with 2.8 in India.[8] This large *level* difference in fertility suggests that there are likely to be differences

[8]Source: United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2017 Revision, custom data acquired via website.

in the *correlates* of fertility within these populations as well. The relationship between fertility and socioeconomic status is well understood to be positive in some present and past populations and negative in others (Schultz, 1981). Vogl (2015) has used the same DHS data source that we study to document that, over recent decades, the gradient between fertility and economic status in developing countries has slowly switched from positive to negative. India and SSA are at different points in this transition, and high fertility has remained positively selective in SSA long after it became negatively selective in India.

As Figure 2 documented in the introduction, these patterns are visible in the Indian and African data that JP studies. Supplementary Appendix Tables A.2 and A.3 report complete results of regressing measures of children's environments on sibsize indicators interacted with the India indicator, for the full birth history (A.2) and for the main height sample (A.3), with similar results across samples. The dependent variables — mothers' height, mothers' BMI at the time of the survey, mothers' literacy, and household urban location — are each important predictors of child outcomes. Because each of these variables is constant among siblings, the patterns in these tables are not confounded by any birth-order effects. For each outcome, Tables A.2 and A.3 show that larger sibsize is more negatively selective in India than in SSA. Indeed, in SSA, mothers who have more children are taller and have more body mass, on average; in India they are shorter and have less body mass. These results are consistent with the visibly distinct implications of sibsize in India and SSA in Figure 2. They indicate that an omitted variable threat to equation 1.1 from fertility and sibsize is not merely a theoretical possibility, but is an observable property of these populations.

2.2 Main result: Adding controls for sibsize and sibsize $\times$ India

In the birth-order literature, there is a standard non-parametric tool described in detail by Blake (1989) and used more recently by Black et al. (2005): a plot of mean outcomes by birth order and sibsize, that is, with means computed separately for each combination of birth order and sibsize. Figure 3 presents such a plot. Observations are children with measured height. For clarity, only the last or next-to-last birth to a child's mother is included in the figure; 97% of the main height sample is either last-born or next-to-last born. The horizontal axis is sibsize, the count of children ever born to the mother. The vertical axis is the residual of HAZ after regression on a set of 119 age-in-months $\times$ sex indicators. Three patterns are clear in the figure: (1) that in India there is a visible downward slope, that is, children born to higher-fertility mothers are shorter, on average; (2) that there is no later-born height disadvantage in India, and perhaps a later-born advantage; and (3) that neither of these patterns is very pronounced in SSA, where sibsize and birth order do not appear to be strong predictors of child height.

A reader may be interested in why we residualize out age from Figure 3. During the first two years of life, stunting and mean height-for-age follow a characteristic pattern in developing countries in which height-for-age falls with age. The height-for-age – age relationship becomes relatively flat by age two. Figure A.1 in the Supplementary Appendix plots this pattern in our sample. Any attempt to estimate an effect of birth order on child height (in a cross-sectional survey of siblings) must therefore control for child age, because earlier-born siblings are older.[9]

Table 2 presents our main result: we compare the results of Equation 1.1 (JP's main specification) with Equation 1.2 (CS' main specification), which includes sibsize $\times$ India controls. The leftmost column of Table 2 reprints the result presented by JP for reference. Column 1 is our replication. Our estimates are quantitatively similar to what JP finds: first-born children in India with height measured in the DHS are taller, on average, than first-born children of the same age in SSA; HAZ differences by birth order in SSA are small; and the average later-born child with height measured in the DHS in India is much shorter than the average first-born with height

[9] We control for age-in-months by sex because this is the level of resolution at which WHO height-for-age norms are defined. Panel (b) of Figure A.3 verifies that the figure is identical if only age-in-months is controlled. Although we believe that Figure A.2, which residualizes out age-in-months by sex, is the appropriate way to depict these relationships, Panel (a) of Figure A.3 replicates Figure A.2 without the age controls, for comparability to JP's Figure 2, which does not control for age. In Panel (a) of Figure A.3, the strong sibsize gradient within India remains visible, but later-born children in both India and SSA appear much taller than earlier-born children of the same sibsize because of the confounding relationships among age, birth order, and HAZ.

measured.

Column 2 adds a vector of controls for sibsize indicators interacted with the India indicator. Note that this is unlike JP's main specification. As the joint F-test of these added indicators shows, these controls substantially improve the fit of the model. This is expected, because of the different implications of high fertility in India and SSA. With the sibsize controls, the sign of the India $\times$ birth order interaction reverses, and is statistically significantly positive in some cases.

For transparency and for a simpler specification, the rightmost columns of Table 2 split the main height sample by region.[10] Columns 3 and 4 of Table 2 regress HAZ on birth order, with and without sibsize controls, for the Indian sample only. Columns 5 and 6 show the results of these regressions in the SSA sample. In the Indian sample, the signs on the indicators for 2nd born and 3rd+ born reverse, from negative to positive, when indicators for sibsize are included among the independent variables.

3 Is there evidence of a first-born son advantage?

3.1 Child sex and first-born sons

JP motivates its analysis with reference to the literature on son preference in India. Although there is no doubt that there is substantial sex discrimination in India, this fact does not necessarily imply a first-born or first-born boy height advantage in India, which is the mechanism that JP proposes for its findings.

JP considers associations between child height and combinations of sex and birth order (Table 5 of JP). As in JP's main result, these results do not hold sibsize constant. In our Appendix, Figure A.5 replicates Figure A.2 separately for Indian boys and Indian girls.[11] Within both sexes,

[10] Splitting the sample by region has the further effect of letting the age indicator controls differ for India and SSA. As a robustness check in the Supplementary Appendix, Table A.4 replicates this result for children who are older than 24 months because, as Figure A.1 shows, among children who are older than 24 months, age is less highly correlated with HAZ.

[11] Note that Figure A.2 and Table 2 have already verified that our result is robust to *controlling* for sex by

there is a negative association between height and sibsize. As in the combined sample, Figure A.5 finds some suggestion within each sex of a later-born height advantage at higher sibsizes, with sibsize held constant.

Table A.14 considers JP's proposal of a special advantage for first-borns and first-born sons. In practice, the DHS data only allow first-borns to be compared with second-borns: among children with measured height who also have a first-born sibling with measured height, over 90% are second-born (as opposed to later birth order). We therefore restrict the sample to sibsizes of 2.[12] Panel A shows that there is no statistically significant difference between India and SSA in the association between being first-born and height, and Panel B shows the same result for an indicator for being a first-born boy.[13]

3.2 In the comparison that the data permit — last-born to next-to-last born — JP's interaction is reversed

Only a small subset of the data is available to learn about the consequences for height of being first-born. This section therefore concentrates on the dimension of birth order that can be studied in these data: being last born, as opposed to next-to-last born, at the time of the survey.

JP codes its birth order independent variables as "2nd born" and "3rd+ born," with first-born as the omitted category. JP's approach therefore focuses on comparisons among children of low birth orders. However, 45% of the main height sample in SSA and 23% in India are birth orders four or later. Less than 10% of the non-first-born main height sample has a first-born sibling whose height was measured by the DHS. As a result, JP's specification of birth order disregards much of the variation in birth order in its sample, and especially in the SSA sample. Table 1

age-in-month indicators; Figure A.5 further fully *interacts* birth order and sibsize by sex within India and finds the same result.

[12] 96% of first-borns with measured height are of sibsize no greater than 2, and including sibsizes of 1 would conflate birth order with sibsize.

[13] The sign of the interaction coefficient, although never statistically significantly different from zero, depends on whether age is interacted with India or not (at different points, JP uses both forms).

summarizes these facts about the structure of the data.

An alternative approach is to measure birth order *relative to last-born children* (at the time of the survey), instead of *relative to first-born children* as JP does. This alternative is more informative for a study of height in the DHS because the available variation in birth order is almost entirely between last-born and next-to-last born children. Indeed, 97% of the children in the main height sample were the last-born or next-to-last of their sibship at the time of the survey. A regression specification that exploits this variation is:

$$h_{imc} = \alpha_1 \textbf{\textit{India}}_c + \alpha_2 \textbf{\textit{India}}_c \times \textbf{\textit{last-born}}_{imc} + \beta_2 \textbf{\textit{last-born}}_{imc} + \beta_1 + \gamma X_{imc} + \varepsilon_{imc}, \tag{3.1}$$

where *last-born*$_{imc}$ is an indicator for a child's birth order equalling its sibsize. This specification corresponds with the approach of Figure A.2 (which may be preferable, because it does not assume a constant, linear association). Equation 3.1 eliminates any mechanical correlation between the birth order variable and sibsize, because birth order is coded relative to sibsize.

Table 3 reports estimates of equation 3.1. Panel A reprints JP's main results from columns 2-5 of its Table 2. Panels B and C implement the same specifications — meaning the same sample restrictions, fixed effects, and controls — as JP's Table 2, but with the sample restricted to the last two births and birth order specified as in equation 3.1. The results in Panel B do not further control for sibsize; the results in Panel C do. In each column of Panels B and C, the coefficient on last-born × India is positive. Therefore, with or without explicitly controlling for sibsize, and with or without mother fixed effects, coding birth order relative to the last-born child is sufficient to reverse JP's result.

4 Mother fixed effects are misspecified for height in the DHS

JP discusses the possibility that sibsize could be an omitted variable in its analysis. Because, at any time, all children of a mother share the same sibsize, a natural idea might be to account for sibsize by controlling for mother fixed effects. Such a fixed-effects strategy is therefore JP's principal response to the threat of omitted variable bias from sibsize. In this section we discuss the reasons why this strategy is ultimately not informative. Unlike in CS' use of the full birth history and unlike in studies of other data in the birth-order literature, mother-fixed-effects regressions are not well-specified for controlling for sibsize to estimate an effect of birth order on height in the DHS height subsample. We discuss the reasons here because they are perhaps counter to intuition: they relate to the structure of the DHS and to the complex relationships among sample inclusion, birth spacing, and the age pattern of HAZ. However, because the mother-fixed-effects robustness check is neither JP's main result nor our central focus, we discuss these issues most fully in supplementary appendix section B.

JP includes a robustness check using fixed effects in column 5 of its Table 2, which is reprinted in our Table 3. Table 3 demonstrated that the fixed-effects result is not robust to a respecification of the birth order variable that better matches the variation in the DHS height sample. Table 4 shows that the fixed-effects result is also sensitive to other details of the regression specification.[14] Because 84% of the mother-fixed-effects sub-sample has exactly two measured heights in a sibship, we restrict the sample to sibships with two measured heights for clarity. The sample is split, across columns, into sibships with sibsize of 2, 3, and 4; otherwise Panel A matches JP's mother-fixed-effects specification. Panel A shows that the sign of the interaction coefficient of interest is inconsistent across sibsizes; comparing Panel A and Panel B shows that the sign of

[14] Other results in Table A.5 in the Supplementary Appendix show further examples. For example, the interaction between India and later birth order is eliminated or reversed under similarly plausible alternative controls for age — including using other controls for age that JP uses elsewhere.

the coefficient of interest is inconsistent across alternative plausible methods of controlling for child age. These results raise a question: Why are mother-fixed-effects estimates so fragile and unreliable for studying birth order in the DHS height sample?

In this section, we briefly provide intuition for why a fixed-effects specification would be perhaps unexpectedly fragile in this case: in short, although mother fixed effects may initially appear promising, fixed effects, too, are undermined by the structure of the DHS. Again, it is critical that the DHS only measures the heights of children under 5 years old. This has several consequences. The main problem is that the strict exogeneity of requirement for fixed effects is violated, as we will explain. But it is also clear that children whose height is measured who also have a sibling young enough to be measured are different from the main height sample. Differences include that children in the fixed-effects subsample have shorter birth spacing (Table A.9) and come from more disadvantaged households (Table A.10). Using fixed effects therefore would estimate a *different* average treatment effect, even if it were without bias.

Perhaps the most critical issue that arises from the mother fixed-effects sample concerns birth spacing: the interval of time between the birth of two siblings. For a variety of reasons discussed in the demographic literature, short birth spacing predicts worse outcomes for later-born siblings (Behrman, 1988). Appendix B documents this well-studied interaction in our data.

The fact that birth order and birth spacing interact to predict child height causes two distinct problems for a mother-fixed-effects approach to identify an effect of birth order on child height. The first problem is that the estimate will be inconsistent because the correlation of birth spacing with the older sibling's age violates the strict exogeneity assumption of fixed effects (Chamberlain, 1984; Wooldridge, 2010). Because of the role of birth spacing, a child's height is predicted by his or her *sibling's* age, conditional on his or her own age and birth order. Because it is an interaction, this violation of strict exogeneity cannot be addressed by merely controlling for birth spacing. Moreover, birth spacing is a property of a sibling pair, not a child, and therefore cannot be controlled for at the child level; to see this, note that first-borns have no prior birth spacing that could be entered as a covariate.

Nor, as Figure A.1 makes clear, can age controls be omitted. This is because the DHS, like other cross-sectional surveys that measure anthropometry, measures children's height at their ages at the time of the survey.[15] As a result, age differs across children and must be controlled. Yet, age is correlated with birth order *within sibling pairs*: the correlation between age-in-months and birth order in the mother-fixed-effects subsample is -0.173, whereas in the main height sample it is only 0.002. Although birth order is correlated with age in the mother-fixed-effects subsample, it is not necessary that birth order be correlated with age in *any* sample representative of a population of potential interest.[16] The correlation occurs because — unlike in the main height sample, where children of any birth order can be any age under five — the mother-fixed-effects subsample is necessarily constrained to those children with at least one sibling who is also under the age of five.

The second problem arising from birth spacing is that, even if the mother-fixed-effects estimate of the coefficient on birth order were unbiased — perhaps because children were all measured at the same age, but at different times, so age need not be controlled — the average treatment effect in the mother-fixed-effects subsample will be more negative than the average treatment effect in the main height sample, or in the full population. This is because birth spacing is shorter in the mother-fixed-effects subsample than in a representative sample. Moreover, a regression that controls for child age and mother fixed effects will identify an effect of birth order

[15]To be clear, the DHS measures other properties of children at other ages: the birth history measures every child's neonatal mortality in the first month of life, for example. The women's questionnaire measures adult women's education in a retrospective survey question that asks about their childhood.

[16]We can see this by imagining alternative sampling strategies. For example, in a sample representative of 48-month-olds in India, age would be uncorrelated with birth order, but no child's siblings would be observed. Alternatively, one can imagine an expensive-to-collect, DHS-like sample in which children are only included in the final dataset if they are alive and under 60 months old in June 2006, but all children were measured on their third birthday. Such a sample would include the same set of children as the DHS (so sibsize would still be highly correlated with birth order), and would still allow last-born and next-to-last-born siblings to be compared (although the mother-fixed-effects subsample would still be unrepresentative of the main height sample in the same way), but age would not be correlated with birth order. Therefore, age would not need to be controlled. Age need not be (and cannot be) controlled in CS' study of age-specific mortality rates.

principally off of the rare cases where birth order is unusual conditional on age and sibsize fixed effects; these will be the cases where birth spacing is very short. Supplementary Appendix B presents further details.

5 Implications: Reconciling results with and without age-censoring and sibsize controls

In the DHS, early-life mortality data are available for all children ever born to the mother by the time of the survey. This is an important contrast to height, which is only measured for births in the five years before the survey. In this section, we reconcile the CS mortality results with the JP height results. That is, we analyze the DHS mortality data in the way that JP analyzed the height data, and as though the mortality data were age-censored in the same way that the height data are. In other words, we intentionally misspecify an analysis of mortality, as a tool to confirm our diagnosis of the height results.

Table 5 presents the results of this exercise. The sample in Table 5 is larger than our main height sample because it matches CS' main mortality sample, which uses complete birth histories and which compares India with the rest of the developing world. Columns 1 and 4 match the age-censoring of JP's sample: children are only included in the sample if they were born within 60 months before each survey. Also matching JP's analysis, in columns 1 and 4 sibsize is not controlled. As in JP's height results, there is now an apparent later-born disadvantage for mortality: the coefficients on birth order interacted with India are positive and increasing.

Columns 2, 3, 5, and 6 account for sibsize. Moreover, they include all children ever born to their mothers, and include only mothers whose last birth was at least five years ago, to focus on mothers who are likely to have completed fertility. In particular, columns 2 and 5 control for sibsize interacted with India, and columns 3 and 6 control for mother fixed effects. In these properly-specified regressions with a non-age-censored sample, India's relative later-born survival advantage is apparent, as in CS. Additionally, in contrast to the large numeric effect that adding mother fixed effects has to JP's coefficients (reprinted here in Table 3), the mortality results are quantitatively stable when mother fixed effects are added.[17]

Therefore, we interpret Table 5 to resolve the puzzle posed by Figure 1. When the mortality data are analyzed in the way that JP analyze the height data, a later-born disadvantage is found. But because this specification is incorrect, it provides no evidence of a later-born disadvantage.

6 Discussion

Because of the correlation between child height and sibsize, the negative correlation between birth order and child height in India cannot be interpreted as a negative effect of birth order. Some results suggest that there may even be a *positive* effect in India of being later-born on child height, rather than the negative effect that JP proposes. Our conclusion, however, is that the structure of the available DHS data — specifically, that children are observed at different ages, and that only the youngest children are observed — prevents researchers from being able to interpret these results with confidence as an effect of birth order on child height.

If there is not a negative effect of birth order on child height in India, that would not be evidence against the existence of important social inequality in India with population-level health consequences. One dimension of social inequality is sex discrimination: female children in India face discrimination that has consequences for their health, and that can depend on the sex of their siblings (Arnold et al., 1998; Pande, 2003; Barcellos et al., 2014). Moreover, in India, sibsize and other outcomes are endogenous to realized child sex because of sex-biased fertility stopping (Clark, 2000). Another dimension of social inequality that matters for child outcomes is caste

[17] Columns 2 and 3 and columns 5 and 6 are not numerically identical pairs (note the summary statistics in the bottom rows), but turn out to be indistinguishable at the number of significant digits reported in the table.

(Hanna and Linden, 2012);[18] yet another is religion (Bhalotra et al., 2010).[19]

If there is a unique later-born *advantage* for child health outcomes in India, as some of the height results presented here suggest there may be, would there be a plausible mechanism that could explain it? CS use complete, retrospective birth history data to show that later-born children in India are more likely to survive the first month of life. This later-born advantage is different in India than in the rest of the developing world, and is specific to neonatal mortality, not to post-neonatal mortality.[20] In a context where poor maternal nutrition is widespread (Coffey, 2015b), these results are consistent with a nutritional trajectory in which young women in India are particularly likely to be underweight when they have their first child or children, and then gain weight as they gain social status over the course of a childbearing career.[21] If this is correct, then there are indeed unique birth-order patterns of early life health in India relative to other developing countries, but they reflect patterns of nutrition and discriminatory treatment among *pregnant women*, rather than discriminatory treatment of *children*.

[18] In its Figure 3, JP notes that average child height is greater in Kerala and the northeastern states than in the rest of India, which JP interprets to be due to matriliny. However, these states are culturally different from the rest of India in several ways, so what JP interprets as an effect of heterogeneity in sex discrimination could, in fact, reflect other cultural differences. Because a reduced importance of caste-related purity norms in Kerala and the northeast make open defecation less common there, less exposure to early-life disease could be partially responsible for the height advantage that JP documents in its Figure 3. Among the main height sample, 47% of all Indian children live in a household that defecates in the open, but less than 5% of children in Kerala do, and only 3%, 4%, and 6% of children in the northeastern states of Tripura, Mizoram, and Manipur respectively do.

[19] In its Table 4, JP shows that the height-birth order gradient is more negative among Indian non-Muslim children than among Indian Muslim children, analogously to JP's India-SSA results. But here, too, JP does not control for sibsize in its DHS height regression. Average fertility is different in these groups, analogously to the India-SSA fertility difference: the average Hindu child with measured height comes from a sibsize of 2.8; the average Muslim child with measured height comes from a sibsize of 3.5. Table A.13 shows that higher-sibsize disadvantages Muslim children in India by less than higher-sibsize disadvantages Hindu children, as measured by mothers' BMI. We also replicate JP's Muslim birth order comparison in Table A.13, and (as in our Table 2 main results for India and SSA) show that the apparent interactive effect disappears when sibsize is controlled.

[20] CS also document higher neonatal mortality among children born to larger sibships — analogously to the downward slope by sibsize in Figure A.2 — so demographic patterns of neonatal mortality in India reflect two countervailing trends, by sibsize and birth order.

[21] Das Gupta (1995) describes an improving profile of women's status and health over the life course in Punjab.

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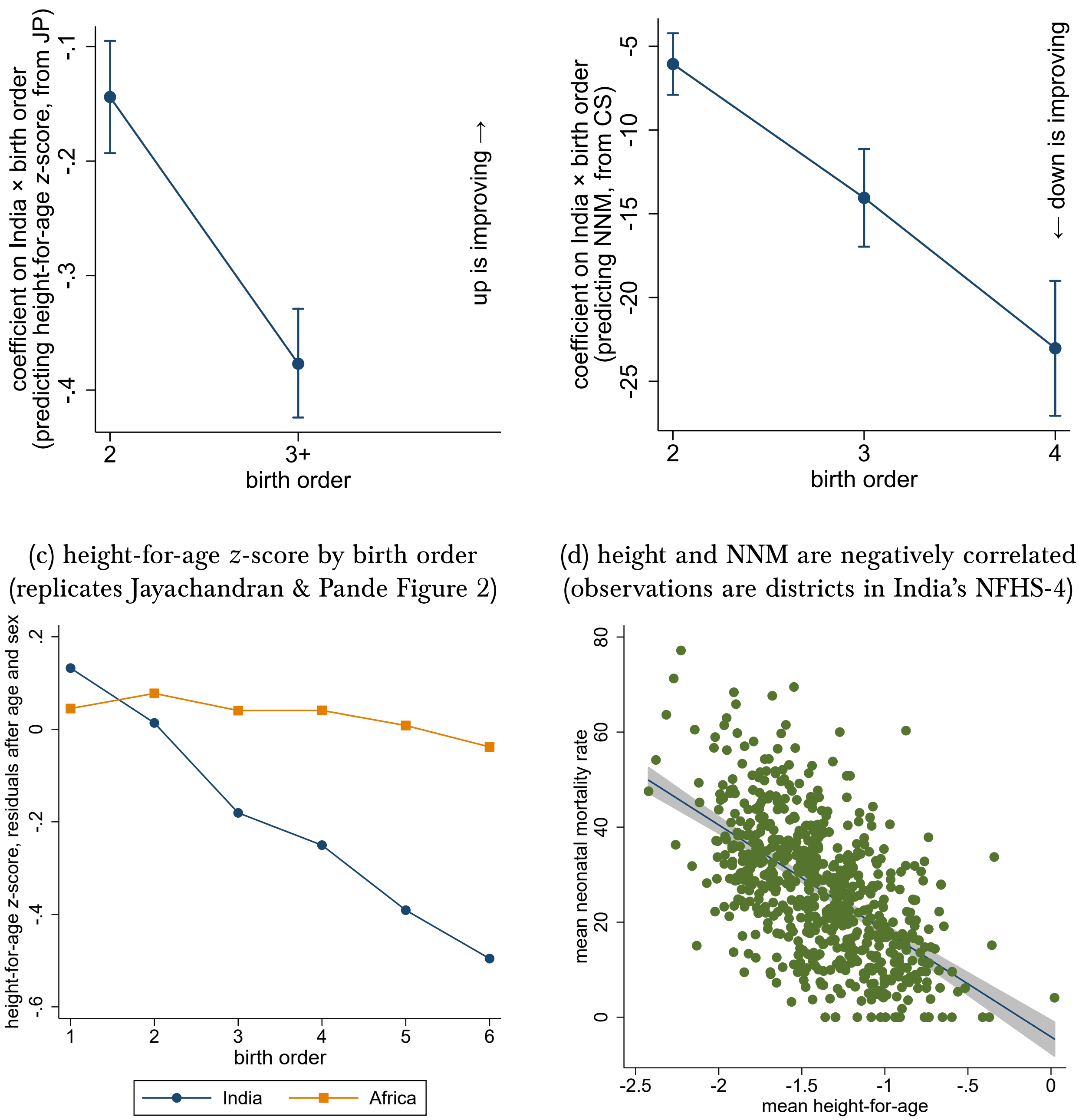
Figure 1: A puzzle: Although height and mortality are correlated in populations, one study finds a later-born height disadvantage in India, while another finds a later-born mortality advantage

(a) later-born **HAZ** disadvantage (Jayachandran & Pande 2017, Table 2)

(b) later-born **mortality** advantage (Coffey & Spears 2019, Table A2)

(c) height-for-age *z*-score by birth order (replicates Jayachandran & Pande Figure 2)

(d) height and NNM are negatively correlated (observations are districts in India's NFHS-4)

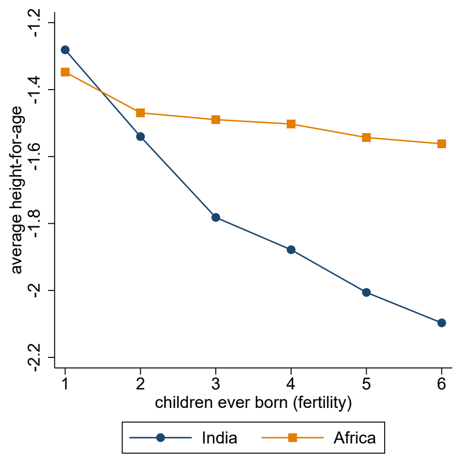


Note: Movements down the vertical axis are improvements for mortality rates and worsenings for height-for-age *z*-scores. Panels (a) and (b) reprint coefficients reported in tables in those papers. Panel (c) is computed by the authors using the same data as JP, described in section 1.1 as our "main height sample." Panel (d), which illustrates that population-level height advantages are correlated with population-level neonatal mortality advantages, is computed from India's most-recent DHS survey (NFHS-4).

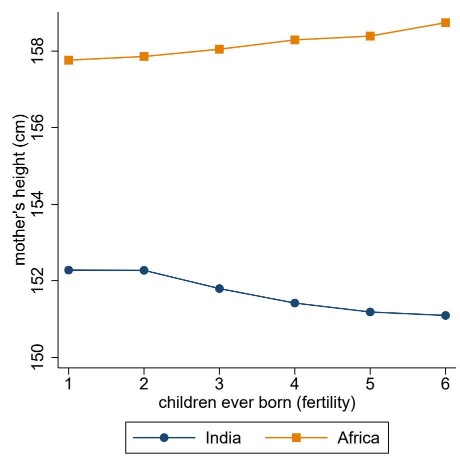
Figure 2: Background: Higher-fertility mothers are more disadvantaged in India, relative to lower-fertility mothers in India, than higher fertility mothers are in Africa

(a) average child's height-for-age z

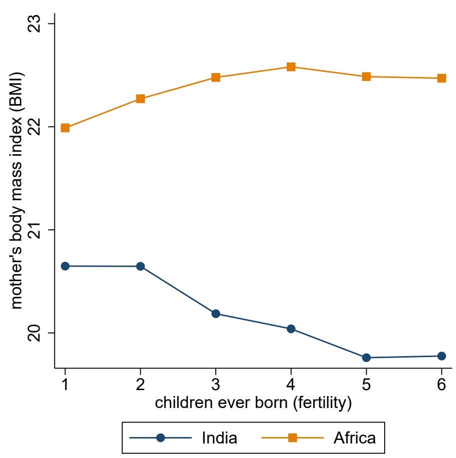
NB: Horizontal axis different from Fig.1c



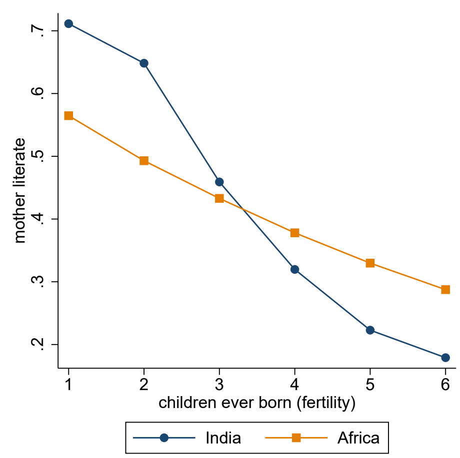
(b) mother's height



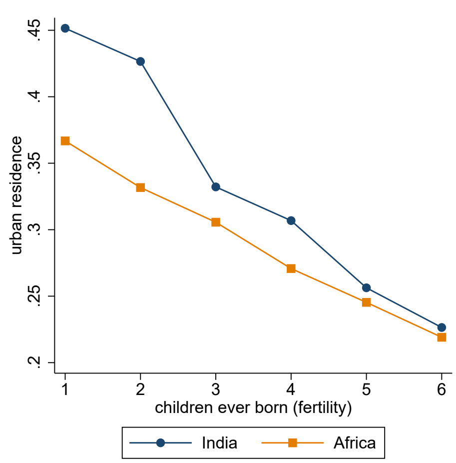
(c) mother's body mass index



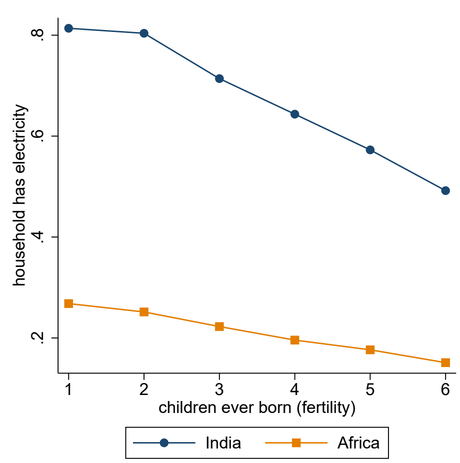
(d) mother literate



(e) household urban

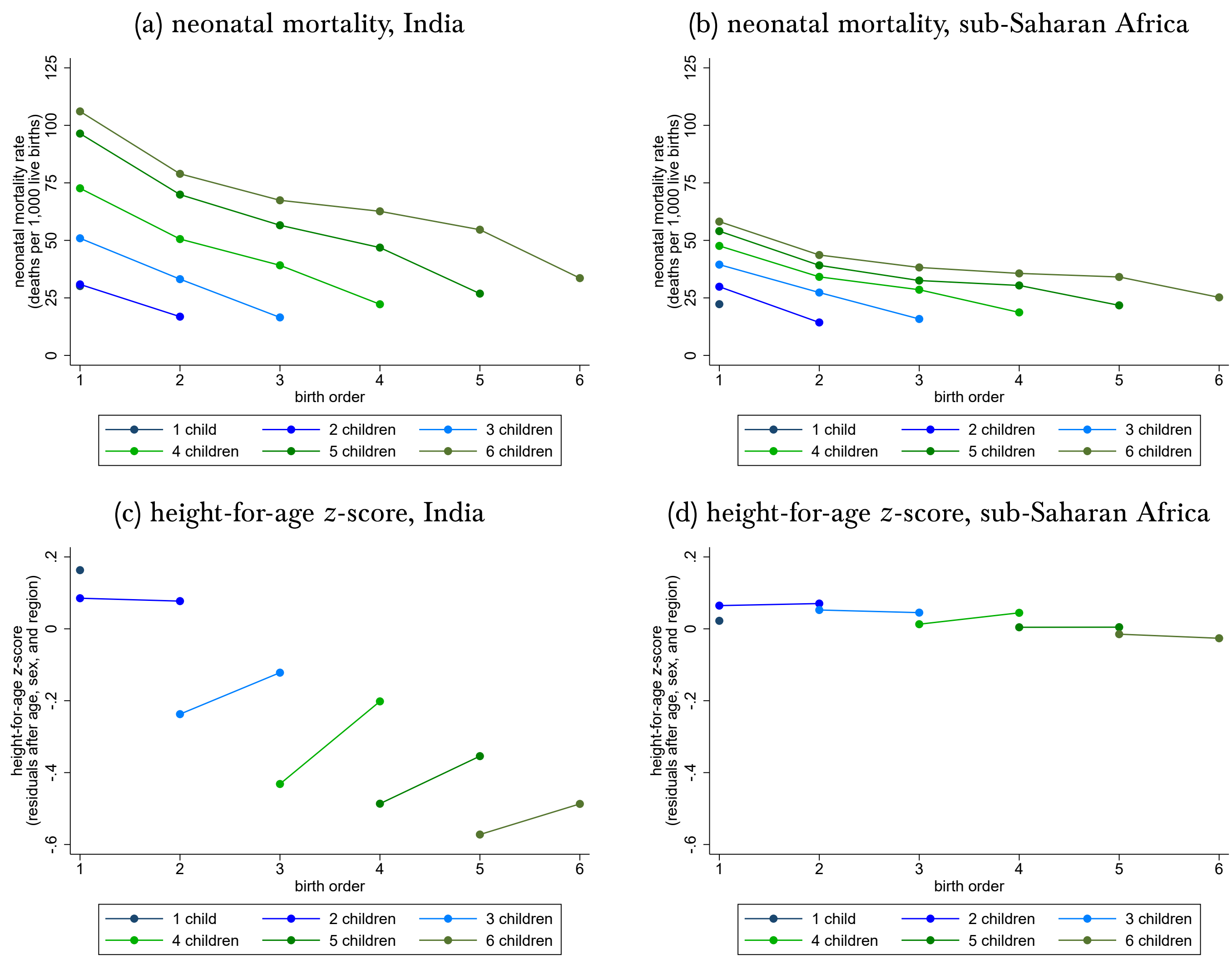


(f) household has electricity



Note: Observe that in every panel, the India line slopes more negatively than does the Africa line. In all panels, the sample is the same as JP and as panel (c) of Figure 1, described in section 1.1 as our "main height sample."

Figure 3: A resolution: Later-born children **of the same sibsize** are relatively advantaged in India, in both height and early-life mortality



Note: Movements down the vertical axis are improvements for mortality rates, but are worsenings for height-for-age. The mortality rate figures (panels a and b) are reprinted from Coffey and Spears (2019). The height-for-age figures (panels c and d) are computed from the main height sample (which is described in section 1.1 and matches JP's data), using only the 97% of observations that are last-born or next-to-last-born at the time of the survey (see table 1 for details on the sample structure). The count of children (in the legend) by which the sample is split is the number of children ever born to the mother by the time of the interview, which is the variable on the horizontal axis of each panel of Figure 2.

Table 1: Demographic structure of main height sample: Birth order and heights per sibship

	child's birth-order-distance from last born						
heights per sibship	0	1	2	3	4	5	total
1	80,737	4,419	196	15	1	0	85,368
2	35,507	34,932	1,420	71	2	2	71,934
3	2,887	2,870	2,877	45	3	0	8,682
4	41	40	40	41	2	0	164
5	1	1	1	1	1	0	5
total	119,173	42,262	4,534	173	9	2	166,153

Note: "Child's birth-order-distance from last born" is (sibsize at the time of the height measurement - birth order). So, because $\frac{119{,}173}{166{,}153} = 72\%$ of the main height sample has a value of 0, 72% of the main height sample is the last born to their mother. "Heights per sibship" is the number of measured heights in a child's sibship; only children with a value of 2 or greater could be in the mother-fixed-effects sub-sample. $\frac{85{,}368}{166{,}153} = 51\%$ of the main height sample is ineligible for the mother-fixed-effects sub-sample in this way.

Table 2: Controlling for sibsize and India × sibsize reverses the India × birth order sign, when estimating relationships with height-for-age z-scores

	(JP)	(1)	(2)	(3)	(4)	(5)	(6)
sample:	Table 2, column 2	India & sub-Saharan Africa		India only		sub-Saharan Africa only	
India	0.092	0.086	0.137				
	(0.018)	(0.021)	(0.026)				
2nd born × India	-0.144	-0.152	-0.011				
	(0.025)	(0.025)	(0.031)				
3rd+ born × India	-0.377	-0.387	0.093				
	(0.024)	(0.025)	(0.049)				
2nd born	0.023	0.032	-0.016	-0.121	0.00463	0.0323	-0.0281
	(0.015)	(0.015)	(0.021)	(0.0193)	(0.0246)	(0.0154)	(0.0217)
3rd+ born	-0.066	-0.045	-0.092	-0.432	0.0634	-0.0442	-0.117
	(0.013)	(0.013)	(0.032)	(0.0213)	(0.0422)	(0.0134)	(0.0327)
sibsize indicators			✓		✓		✓
(joint F test)			$F = 163$		$F = 20$		$F = 207$
			$p < 0.0001$		$p < 0.0001$		$p < 0.0001$
n	168,108†	166,153	166,153	41,972	41,972	124,181	124,181

Note: In all columns the dependent variable is the child's height-for-age z-score. The column labeled "(JP)" reprints results from Table 2 of the published paper; the rest of the columns are our analysis. Sibsize indicators include all available sibsizes, interacted with an India indicator in columns 1 and 2; F-tests report tests that these indicators jointly improve the fit of the model. Only age controls are further included in columns 1-6. We follow JP by including all available birth orders, top-coding as "3 or more," and controlling for age as 59 age-in-months indicators. In the Supplementary Appendix, Table A.4 replicates this analysis using only children at least 24 months old. Standard errors are clustered by survey PSU.

† For a discussion of the 1% difference between JP's height sample size and our main height sample, see footnote [4] on page 7.

Table 3: In estimating HAZ relationships, the negative coefficient on the "India × later birth order" interaction is reversed by a coding of birth order that matches the variation in birth order

	(2)*	(3)	(4)	(5)
Panel A: Reprinting columns 2-5 of JP's main result, JP's Table 2				
India × 2nd born	-0.144	-0.161	-0.11	-0.243
	[0.025]	[0.027]	[0.063]	[0.048]
India × 3rd+ born	-0.377	-0.227	-0.193	-0.436
	[0.024]	[0.032]	[0.092]	[0.085]
2nd born	0.023	-0.011	-0.097	-0.167
	[0.015]	[0.017]	[0.053]	[0.027]
3rd+ born	-0.066	-0.118	-0.169	-0.334
	[0.013]	[0.019]	[0.074]	[0.044]
n	168,108	167,737	66,566	83,228
Panel B: Last two birth orders only, no sibsize controls, our computation				
India × last-born	0.159	0.159	0.0689	0.244
	(0.0213)	(0.0253)	(0.0353)	(0.0840)
last-born	0.000354	-0.147	-0.0801	-1.315
	(0.0134)	(0.0145)	(0.0255)	(0.0517)
n (last or next-to-last)	161,435	160,898	63,391	74,762
Panel C: Last two birth orders only, with sibsize controls, our computation				
India × last-born	0.0835	0.115	0.0474	0.244
	(0.0216)	(0.0262)	(0.0364)	(0.0840)
last-born	0.00962	-0.170	-0.110	-1.315
	(0.0135)	(0.0152)	(0.0265)	(0.0517)
sibsize & India × sibsize	yes	yes	yes	yes
n (last or next-to-last)	161,435	160,898	63,391	74,762
sample:	main height	main height	completed fert.	mother FE
child age	yes	no	no	no
child age × India	no	yes	yes	yes
literacy × India	no	yes	yes	no
mother's age × India	no	yes	yes	no
PSU FEs	no	yes	yes	no
mother FEs	no	no	no	yes

Note: In all columns the dependent variable is height-for-age z-score. Although JP compares first-born to later-born children, the DHS height sample is structured to compare last-born to earlier-born children. This is because 97% of observations in the main height sample were last or next-to-last born of their sibsize when surveyed.
*The leftmost column is numbered (2) to correspond to column 2 of JP's Table 2; its column 1 documents the average India-SSA difference. Panel A reprints JP's results. Panels B and C are our computations. In Panels B and C standard errors are clustered by survey PSU.

Table 4: Mother fixed effects results are unstable: The sign of the India × birth order interaction is unstable across sibsizes and depends on how age is controlled

	(1)	(2)	(3)
sibsize	2	3	4
birth orders	1 & 2	2 & 3	3 & 4
Panel A: With age-in-months × India FEs, following JP			
later-born × India	-0.0328	-0.119	0.422†
	(0.134)	(0.179)	(0.230)
later-born	-0.887***	-1.084***	-1.425***
	(0.0995)	(0.116)	(0.126)
mother fixed effects	yes	yes	yes
Panel B: With age-in-months FEs and mother FEs			
later-born × India	0.000981	0.135**	0.389***
	(0.0403)	(0.0521)	(0.0655)
later-born	-0.906***	-1.164***	-1.443***
	(0.0733)	(0.0940)	(0.108)
mother fixed effects	yes	yes	yes
Panel C: With age-in-months × India FEs as in A; no mother FEs			
later-born × India	-0.00586	0.0971	0.140
	(0.0932)	(0.121)	(0.155)
later-born	-0.275***	-0.401***	-0.347***
	(0.0707)	(0.0812)	(0.0872)
mother fixed effects	no	no	no
n (children)	20,374	15,670	11,850
mothers:	10,187	7,835	5,925
children per mother:	2	2	2

Note: In all columns the dependent variable is the child's height-for-age z-score. Note the difference in signs across sibsizes in Panel A, with the specification held constant. Note also the differences across panels in column 2. Each column uses the exact same set of observations in Panels A, B, and C; the only difference is whether age-in-month fixed effects are interacted with an India indicator and whether mother fixed effects are used. The Panel A specification, in which age is interacted with India, is what is used in JP's mother-fixed-effects specification, in column 5 of Table 2 of the published paper. We use age-in-months controls, rather than age-in-months × sex controls (which is our preferred specification, and which we use elsewhere) in order to match JP's specification in this way; results available upon request and in our posted log file show that controlling for age-in-months × sex makes very little difference. Standard errors are clustered by survey PSU.

Table 5: A demonstration of the effects of misspecification: Analyzing mortality on an age-censored subsample while omitting controls for sibsize finds the same birth order pattern that JP find for child height

	(1)	(2)	(3)	(4)	(5)	(6)
dependent variable:	IMR	IMR	IMR	NNM	NNM	NNM
sample:						
age-censored	✓			✓		
not age-censored		✓	✓		✓	✓
sibsize controls:						
none	✓			✓		
sibsize × India indicators		✓			✓	
mother fixed effects			✓			✓
birth order 2 × India	1.747	-4.510***	-4.510***	9.446***	-5.301***	-5.301***
	(1.302)	(1.137)	(1.137)	(0.932)	(0.912)	(0.912)
birth order 3 × India	4.330**	-10.44***	-10.44***	8.028***	-9.574***	-9.574***
	(1.599)	(1.395)	(1.395)	(1.099)	(1.098)	(1.098)
birth order 4 × India	10.11***	-21.28***	-21.28***	11.94***	-19.15***	-19.15***
	(2.140)	(1.706)	(1.706)	(1.476)	(1.354)	(1.354)
birth order 5 × India	13.47***	-34.69***	-34.69***	13.07***	-28.64***	-28.64***
	(2.740)	(2.158)	(2.158)	(1.898)	(1.716)	(1.716)
birth order 6 × India	11.18***	-44.69***	-44.69***	14.45***	-39.59***	-39.59***
	(2.666)	(2.624)	(2.624)	(1.876)	(2.086)	(2.086)
birth order and India indicators	✓	✓	✓	✓	✓	✓
n	1,306,124	2,727,480	2,633,157	1,627,791	2,727,480	2,633,157
fraction of sample last or next-to-last born:	0.862	0.434	0.414	0.875	0.434	0.414
correlation between birth order and sibsize:	0.912	0.580	0.553	0.916	0.580	0.553

Note: IMR = infant mortality rate; NNM = neonatal mortality rate. The age-censored sample, as in JP, includes only and all children who were born within the 60 months before the survey; this matches the restriction that height is measured for children under 5. The non-age-censored sample, as in CS, does not restrict the sample based on age or birth order, but does exclude any birth to a mother who has given birth within the last 60 months, in order to focus the sample on women who have completed childbearing. Columns 1 and 4 match the specification in column 2 of JP's Table 2.

This Supplementary Appendix serves two purposes. One purpose is to provide supplementary exhibits that support our conclusions with extra details and robustness checks. Section A briefly summarizes the role of each of the Supplementary Appendix exhibits in our analysis.[22]

The other purpose is to explain why JP's two primary robustness checks — mother fixed effects and the "completed fertility" subsample — find the results that they do. Section B discusses JP's mother-fixed-effects robustness check in greater detail than in the main text. Although mother fixed effects are somewhat tangential to the main observation of our paper — that the correlation of height and birth order in the Indian DHS in fact reflects sibsize — we elaborate on the fixed-effects results here because this case differs from the familiar intuition of a constant, linear, additive group effect. A key part of the discussion of the use of mother fixed effects in Section B is the observation that birth order and birth spacing interact to predict child height. Section C considers the completed fertility subsample: this subsample is importantly dissimilar to the main height sample; the regression that JP presents using it is sensitive to its controls, and especially to the fact that the sample includes multiple births, such as twins. Section D provides references for material cited in the supplementary appendix.

A Overview of the supplementary appendix

The Supplementary Appendix contains the following figures and tables:

The relationship between height-for-age z-scores and age in early life

- Figure A.1: Height-for-age z-scores by birth order and sibsize in India and sub-Saharan Africa, locally weighted regressions by age. This shows HAZ falling in age for the first two years. This pattern makes age controls an important part of studying HAZ, especially because differences in early life mortality mean that average age is different in India and SSA, as Table A.1 documents.

Robustness of Figure A.2's non-parametric analysis

- Figure A.3: Robustness of Figure A.2 to alternative residualization, or none.
- Figure A.4: HAZ by birth order and sibsize in India and sub-Saharan Africa restricted to JP's "completed fertility" subsample, residuals after age and sex. The similarity of the pattern in this figure to the pattern in Figure A.2 verifies that the completed fertility results are not due to differences in this pattern in that subsample.

[22] Not all of the analyses we present represent approaches that we would recommend for an effort to estimate an effect of birth order on height in these data, but we nevertheless include a wide range of robustness checks for completeness.

- Figure A.5: HAZ by birth order and sibsize in India, by child sex. This figure is discussed in section 3.1; it verifies that the same correlation between height and sibsize is apparent for girls and boys separately.

Further details on the DHS sample studied by JP

- Table A.1: The average child with measured height is older in India than in SSA: the magnitude of the difference depends on sibsize and on the particular subsample.
- Table 1: Demographic structure of main height sample: Birth order and heights per sibship. This table tabulates the make-up of the sample by birth order and by eligibility for the mother fixed-effects sub-sample, meaning it counts observations according to the number of *siblings* born to the same mother who have measured heights.
- Table A.2: Higher sibsize predicts worse household contexts by more in India than in SSA (full sample from birth history).
- Table A.3: Higher sibsize predicts worse household contexts by more in India than in SSA (main height sample).

Robustness of Table 2's control for sibsize and sibsize × India

- Table A.4: Replication of Table 2 only including children at least 24 months old.
- Panel B of Table 2 replicates the main result with birth order up to four (rather than 3+ as in JP) and with age-in-months × sex controls; results available on request confirm that the main result is robust to further combinations and specifications of these variables.
- Table A.14 investigates JP's hypothesis that first-borns or first-born boys are at a special advantage in India. The Table concentrates only on sibsizes of 2, because 90% of children with measured height who have a sibling who is first-born and who has measured height are of birth order 2; this table excludes first-born children who have no siblings. There is no statistically significant interaction in any case; the sign of the interaction depends on how age is controlled.
- Table A.13 responds to JP's Table 4, which includes a result showing that later birth order has a more negative gradient with child height among non-Muslims in India (who are mostly Hindu) than among Muslims. Here sibsize is again an omitted variable, just as in JP's main result: sibsize is higher, on average, among Muslims than Hindus. JP's Hindu-Muslim robustness check is not robust to controlling for sibsize: higher sibsize Hindu children in India have a lower-BMI mother at the time of the survey by a more negative gradient than higher-sibsize Muslim children in India do.
- Figure A.7 qualitatively replicates our main result in the India Human Development Survey, which JP uses in a robustness check.

Further details on mother fixed effects

- Table A.5: The table discussed in the text, demonstrating the instability of mother fixed effects with alternative controls for age.
- Table A.6: Fixed-effects results depend on functional form, part 1: The India × birth order interaction depends on how age is controlled and how birth order is coded.
- Table 4: Fixed-effects results depend on functional form, part 2: The India × birth order interaction is inconsistent across sibsizes and depends on how age is controlled. Adding fixed effects to balanced pairs changes the sign of the interaction.
- Table A.10: Households and mothers are more disadvantaged in the mother-fixed-effects subsample than in the main height sample, especially in India. Therefore, with any non-linearity, the average "effect" of birth order will be different in the mother-fixed-effects subsample.

Birth spacing interacts with birth order and is differently distributed in different subsamples; this interaction is a key threat to the strict exogeneity assumption for mother fixed effects

- Table A.7: Because birth spacing interacts with birth order, mother fixed effects is misspecified for height in the DHS.
- Table A.8: Robustness check of Table A.7 using sibsize 3 rather than sibsize 2.
- Figure A.6: Implicit regression weighting is greater at shorter birth spacing, especially with mother fixed effects. Thus, fixed effects will upweight observations with negative effects of birth order in computing an average "effect" of birth order.
- Table A.9: Birth spacing is lower among the subsample with two measured heights per mother (the mother-fixed-effects subsample) than in the main height sample.
- Table A.11: In the mother fixed-effects-subsample, birth spacing is lower in India than in sub-Saharan Africa.
- Table A.12: Low birth spacing has more severe consequences for child height where maternal nutrition is poor; maternal nutrition is worse in India than in sub-Saharan Africa.

The "completed fertility" subsample

- Table A.15: Controlling for sibsize in the "completed fertility" subsample reverses the negative birth order gradient in India. This table replicates the height - birth order gradients, without and with sibsize controls, in JP's "completed fertility" subsamples of Indian and SSA children. It does not top-code later-order births as "3+" but instead separates third-borns, fourth-borns, and fifth-borns. In India, later-born children of the same sibsize are at least as tall as earlier-born children, on average, even in the completed fertility subsample.

- Table A.16: The completed fertility subsample differs from the main height sample, and selects for different mother characteristics in India and SSA. In particular, this table shows that the "completed fertility" subsample selects for older mothers at higher sibsizes in SSA.

- Table A.17: The India × birth order interaction is sensitive to specification choices in JP's "completed fertility" robustness check. This table replicates JP's completed fertility regression (column 4 of JP's Table 2). In Panel A, it uses JP's coding of birth orders (1, 2, and 3+). In Panel B, it uses Table 3's coding of birth order as last-born or next-to-last born (See section 3.2. In short, Table 3 shows that the India × last coefficient is positive for a range of specifications.) JP's coefficient is sensitive to its inclusion in the sample of the 1.4% of Indian observations and 3.7% of SSA observations that are multiples (twins, triplets); the rest of our analysis follows Black et al. (2005) in omitting these observations. Removing these observations reduces the coefficient by about half in absolute value; removing controls sequentially further changes the coefficient.

- Table A.18 shows that our main finding — that JP's negative interaction between India and being later-born is reversed either by controlling for sibsize or by focusing on the last two births of a sibsize — is robust to including multiple births (twins, triplets) in the sample. This is important because Table A.17 shows that JP's "completed fertility" subsample results are sensitive to the exclusion of these observations, which JP includes. Table A.18 also shows that our pure replication very closely matches JP's main result when we match JP's sample in that way; compare Table 2.

B Mother fixed effects

This section provides further detail on section 4, which shows that mother fixed effects are not a robust approach to estimating an effect of birth order on height using DHS data. Mother fixed effects are a small part of JP's analysis, appearing in only one of the nine columns in its main result table. Yet, we describe the facts and econometrics of mother fixed effects in detail, because this case may be unintuitive. Familiar intuition interprets fixed effects as a catch-all control for group properties; however, JP's case is too far from a standard linear fixed-effects model of constant, additive effects for such intuition to hold.

Table A.5 demonstrates that, in a mother-fixed-effects regression predicting height-for-age z-scores, the sign of the India × birth order interaction depends on which age controls are used and on how birth order is coded. The text discussed columns 1 and 2. To simplify the interpretation of the coefficient on the India × birth order interaction, columns 3 through 5 of Table A.5 restrict the sample to the last and next-to-last children born in each sibship. This omits 7.5% of the mother-fixed-effects subsample described in section 1.1, and it provides a balanced panel of sibling pairs. This change allows us to use a coefficient for "last-born" as the independent variable, instead of a child's numerical birth order. Using "last-born" as an independent variable simplifies the interpretation of the coefficient as a test of the hypothesis that there is a later-born disadvantage in India. This is because, in columns 1 and 2 of Table A.5, and in JP's fixed-effects result, "2nd born" sometimes refers to an earlier-born child (children of birth order 2 in sibsizes of 3) and sometimes refers to a later-born child (children of birth order 2 in sibsizes of 2). There is no reason to expect a constant, additive effect of "being second born" independent of child age and the structure of the sibship. Additionally, comparing last-born to next-to-last born considers evidence from children whose birth orders are greater than three (49% of the fixed-effects sub-sample in SSA has a birth order greater than three; two-thirds are three or greater). In each of columns 3 through 5, relative to next-to-last born children, last-born children are *taller* in India relative to in SSA. This is a reversal of JP's result and is true no matter how age is controlled: as age indicators, as age indicators interacted with India, or even as a linear age control (which we include for illustration, despite the non-linear relationship between age and height). Section 3.2 uses the main height sample to further explore this approach to coding birth order. Table A.6 extends Table A.5 to further cases. It finds that substituting sex × age indicators for age indicators does not qualitatively change any conclusion of Table A.5. This suggests that our finding of non-robustness of fixed effects is not driven by differences between boys and girls.

The mother-fixed-effects estimate is also sensitive in other ways. The results in columns 1, 2, and 3 of Table 4 show mother-fixed-effects estimates of India × last-born for samples containing 1st and 2nd borns (in sibsizes of 2), for 2nd and 3rd borns (in sibsizes of 3), and for 3rd and 4th borns (in sibsizes of 4), respectively. The sign of the coefficient on the India × last-born interaction is not stable across sibsizes in mother-fixed-effects specifications. Moreover, comparing results in Panel A, which uses mother fixed effects, to results in Panel C, which does not control for mother fixed effects, shows that even in balanced panels of matched pairs (where birth order cannot be correlated with sibsize), the sign and magnitude of the coefficient depends on whether or not mother fixed effects are included.

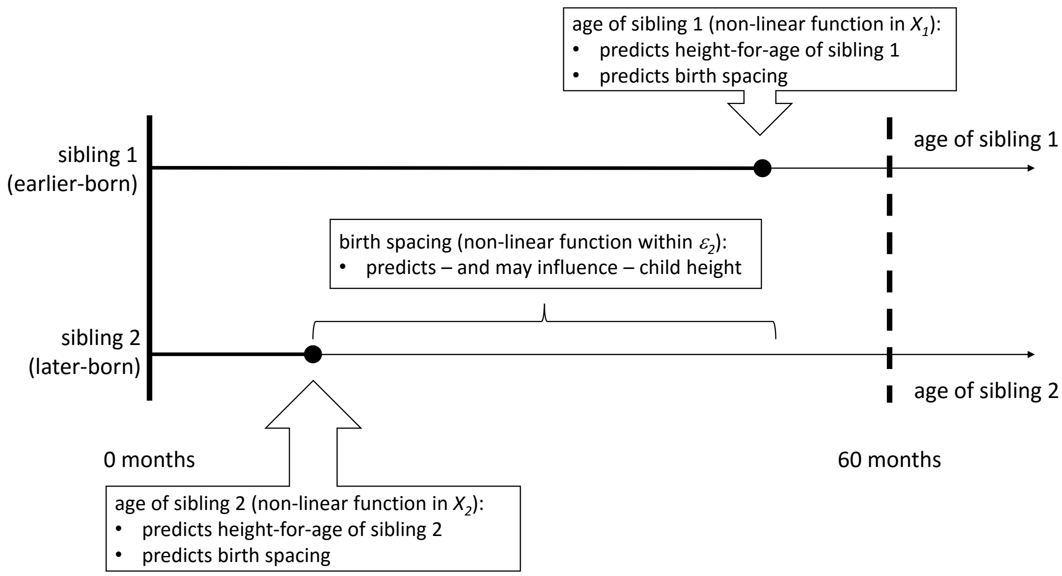
Why are the mother-fixed-effects results so fragile, and what does that suggest about the structure of the mother-fixed-effects subsample? The rest of this Section considers one key reason why a mother-fixed-effects strategy does not produce robust estimates of the population-level average effect of birth order on child height, in these data. A critical fact is that birth spacing interacts with birth order to predict child height: a later-born sibling is more likely to be shorter than an earlier-born sibling if the interval between births is short. This matters in part because average birth spacing is smaller in the mother-fixed-effects subsample. Because this relationship is an interaction, it is not adequately resolved by controlling for birth spacing. Additionally, birth spacing is highly correlated with the ages of both siblings.

Section B.1 notes a literature on the econometrics of fixed effects in cases of non-linearity. Section B.2 briefly summarizes evidence in the literature on the relationship between birth spacing and health outcomes. Section B.3 examines the interaction between birth order and birth spacing to predict height in the DHS data, and discusses the consequences for a mother-fixed-effects strategy that aims to identify an effect of birth order on child height.

B.1 Fixed effects, strict exogeneity, and non-linearity

Early-life is a critical period in human development, featuring complex, non-linear partial correlations among demographic variables. The econometric literature suggests that fixed-effects estimates may be unreliable in highly non-linear cases where inclusion in the estimation

Figure B.0: The strict exogeneity assumption of mother fixed effects is violated



subsample depends on variables that predict the outcome (in this case, child height).

In the case of this mother-fixed-effects identification strategy, consistency of regression coefficient estimates requires a strict exogeneity assumption that the expectation of the error term — the residual predictors of a child's height — is zero, conditional on the independent variables — the child's birth order, its sibling's birth order, and the ages of both siblings. However, these independent variables predict birth spacing, a predictor of child height that interacts with birth order. Fixed effects are generally not consistent in the presence of heterogeneous treatment effects of this type (Gibbons et al., 2014; Imai and Kim, 2014). Figure B.0 diagrams the violation of strict exogeneity described here. As we describe in section B.3, the correlation between birth order and child height depends upon the interval since the prior birth.

Consider the following fixed-effects regression equation (B.1), which JP estimates in its fixed-effects robustness check. Equation B.1 is identical to equation 1.1 except for the addition of mother fixed effects, δ_{mc}:[23]

$$\begin{aligned} h_{imc} \quad = \quad & \alpha_2 \textbf{\textit{India}}_c \times \textbf{\textit{second-born}}_{imc} + \alpha_3 \textbf{\textit{India}}_c \times \textbf{\textit{third-or-later-born}}_{imc} \\ & + \beta_2 \textbf{\textit{second-born}}_{imc} + \beta_3 \textbf{\textit{third-or-later-born}}_{imc} + \gamma X_{imc} + \delta_{mc} + \varepsilon_{imc}. \end{aligned} \tag{B.1}$$

The subscript i indexes earlier-born (shown as "sibling 1" in Figure B.0) and later-born siblings (shown as "sibling 2" in Figure B.0). The vector of child-specific controls X includes controls for age-in-months. Strict exogeneity requires that $E[\varepsilon_2 X_1] = 0$. But, as the diagram shows, this requirement is not met, because sibling 2's residual predictors of height (ε_2) include a non-linear function of birth spacing interacting with birth order, and birth spacing is predicted by sibling 1's

[23]We note that as a result of the addition of the mother fixed effects, the India indicator no longer appears.

age, which is included in X_1. Omitting age controls is not a solution to this problem, because younger siblings have greater HAZ, on average (see Figure A.1). Indeed, without age controls later-born siblings will appear to be much taller than earlier-born siblings, a misleading result.

Further, even if a mother-fixed-effects strategy could estimate the average effect of being later born without bias,[24] it would nevertheless be true that the average treatment effect of birth order in the mother-fixed-effects subsample would not be the same as the average treatment effect of birth order in the full population (or even in the main height sample). This issue arises from the fact that the DHS only measures the heights of children under five years old, which is represented by the dashed vertical line at 60-months of age in Figure B.0. Mother-fixed-effects estimates are therefore necessarily identified off of sibling pairs for whom birth spacing is unusually short compared to the full population of children. (The fact that birth spacing is shorter in the mother-fixed-effects subsample will be documented in section B.3.)

Finally, Angrist (1998) notes that in cases of parameter heterogeneity, regression will effectively reweight the sample to emphasize observations where the variance of the independent variable of interest is large conditional on the other independent variables. In this case, children for whom birth order is surprising conditional on age and sibship fixed effects – that is, observations for whom the variance of birth order is high conditional on age – are, on average, observations with low birth spacing. As a result, the weighted average treatment effect returned by mother fixed effects will emphasize the effect of birth order in observations with low birth spacing, even beyond the extent to which the mother-fixed-effects regression over-includes these observations. Figure A.6 demonstrates that the conditional variance of birth order given age is greatest where birth spacing is low, especially when mother fixed effects are used.

B.2 Literature: Birth spacing interacts with birth order

A large literature documents that in developing country contexts low birth spacing is associated with poor child health (Winikoff, 1983; Curtis et al., 1993; Rutstein, 2005; Conde-Agudelo et al., 2012). Behrman (1988) documents that, within rural Indian households, the length of the interval between two children's births is a predictor of nutrition indicators.

In this case, there are at least two reasons birth spacing may predict child height: direct effects on children of birth spacing, and selection across households and mothers. Short birth intervals have negative impacts on child health in part indirectly through maternal depletion, as mothers do not have the opportunity to prepare physiologically for the later pregnancy. Short birth intervals are also associated with poorer families and lower-social-status mothers (Murphy and Wang, 2001), so even if birth spacing had no direct effect, it would be predictive.[25] Because

[24]This would be true if the same sample of children were measured each at the same age (instead of at the same time, see page 19 of the main text), so there would be no need to control for age.

[25]Moreover, because these predictive correlates of birth spacing can change over the course of a mother's childbearing career, they may not be subsumed in mother fixed effects, even absent other concerns about a fixed-effects strategy. For example, a mother's intrahousehold social status could improve between her second and third birth, which may lead to longer spacing between her second and third births relative to her first and second births. This would result in better maternal nutrition in her third pregnancy, and better health outcomes for the third birth.

all of these factors can operate simultaneously, identifying a causal effect of birth spacing can be a complex challenge (Potter, 1988; Kozuki et al., 2013). Our goal is only to demonstrate that birth spacing is an important predictor of child outcomes that statistically interacts with birth order.

B.3 Consequences for using mother fixed effects: Evidence from JP's data

Table A.7 investigates the consequences of mother fixed effects in JP's data. The table gradually decomposes the difference between, on the one hand, a regression like Equation 1.1's simple correlation of HAZ with birth order in the main height sample and, on the other hand, a regression with mother fixed effects.

In Table A.7 only children from sibsizes of 1 or 2 are included; Table A.8 replicates the result with sibsizes of 2 or 3. In both tables, Panel A uses data from India and Panel B uses data from SSA. The 120 age-by-sex indicators used in Table 2 have been replaced with 30 indicators for sex by age in four-month bins, so that age and birth spacing are not perfectly colinear with mother fixed effects.

Column 1 presents a version of JP's main result: among children of sibsizes 1 or 2, the average second-born is shorter than the average first-born in India but not in SSA. This comparison is inappropriate because second-borns, who all necessarily come from sibsizes of 2, are compared with first-borns, who could come from sibsizes of 2 or from sibsizes of 1. Column 2 therefore excludes children who are the first-and-only born to their mother, and the difference between India and SSA (seen by comparing Panel A and Panel B) disappears. Note that column 2 includes first-born and second-born children of sibsize 2, whether their mother has one or two children with measured height. Column 3 preserves the sample from column 2 and interacts birth order with birth spacing, demeaned so that the average birth spacing of second borns in that region (India or SSA) is coded to be zero. The point estimates on being second born are similar in India and SSA, and the positive coefficients on second born indicate that second borns are taller, on average, at the mean birth spacing for that region.

Column 4 changes the sample to the mother-fixed-effects subsample — that is, to children with two measured heights per mother — but does not include mother fixed effects. In this subsample, the coefficient on later-born becomes very negative. This can be explained by the fact that birth spacing is low in this subsample: column 5 includes an interaction of being second born with the birth interval between the first and second born children (demeaned to the sample mean of birth spacing for all second borns in that region), and the estimates return to almost precisely what they were in the full sample in column 3. The similarity of the coefficients in columns 3 and 5 suggests that birth spacing is an important difference between children in sibships of 2 in the main height sample and children in sibships of 2 in the mother-fixed-effects subsample.

Finally, columns 6 and 7 add the mother fixed effects to the sample used in columns 4 and 5. The pattern of the sign of the coefficient on second born remains the same (negative in column 6 which omits the birth spacing interaction, positive in column 7 which includes it), but the coefficient sizes become much larger in absolute value. Taken at face value, the fixed effect estimate in column 6 suggests that a five-year-old girl will be 4.2 centimeters shorter, on average, than her older sister was on her fifth birthday — or, according to column 7, over 7 centimeters taller. Because the WHO reference tables indicate that mean height for a four year old is about 102 centimeters and mean height for a five year old is about 109 centimeters, this large birth order difference, if a causal effect, would be more than a full year of child growth.

In light of the evidence in Table A.7 that birth spacing interacts with birth order to predict child height, further results provide evidence consistent with the fact that the mother-fixed-effects regression used by JP is confounded by a negative interaction between birth spacing and India. Tables A.9, A.10, A.11, and A.12 provide details about the mother-fixed-effects subsample which we summarize here:

- Table A.9 shows that average birth spacing is lower in the mother-fixed-effects subsample than in the main height sample.

- Table A.10 shows that children in the mother-fixed-effects subsample are disadvantaged relative to children in the full height sample, especially in India. For example, Indian children in the mother-fixed-effects subsample are 0.12 HAZ standard deviations shorter than Indian children in the main height sample, on average. In SSA, the difference is only 0.03 standard deviations.

- Table A.11 shows that in the mother-fixed-effects subsample, average birth spacing is lower in India than in sub-Saharan Africa. This may appear surprising because fertility is lower overall in India; however, childbearing in India tends to be concentrated in a short childbearing career when mothers are young (Coffey, 2015).

- Table A.12 shows that birth spacing interacts with birth order to predict child height more steeply where maternal nutrition is poor. It also shows that maternal nutrition is worse in India than in SSA, on average. As we explain in the note to the table, we use a mothers' Body Mass Index (BMI) at the time of the survey as an indicator of maternal nutrition. This is a noisy measure of what a woman's nutrition would have been during pregnancy.

Finally, we note that because these observations are about interactive effects (meaning, parameter heterogeneity across observations in the effect of birth order) combined with changing samples, none of these issues would be addressed by *controlling* for birth spacing, in the fixed-effects regression or otherwise.

C Regression in the "completed fertility" subsample

In column 4 of its Table 2, JP reports a robustness check intended to address endogenous fertility by restricting the sample to a "completed fertility" subsample: children of mothers who have been sterilized, who are infecund, or who report not wanting more children.[26] In this section, we

[26] Over half of JP's completed fertility sample in India would be classified by demographers as at risk of pregnancy, because most of them are of fecund age and are not using contraception (although abortion is widely available in

investigate the correlation between child height and birth order in this subsample. In Figure A.4 we compare India and SSA in the the completed fertility subsample, replicating Figure A.2 with only these observations: as in the main height sample, we find that children of higher sibsize are shorter, on average, in India, and that later-born children of the same sibsize are at least as tall or taller in India as earlier-born children. Table A.15 presents regressions: as in the full Indian sample, we find that HAZ is negatively associated with birth order if sibsize is not controlled, but controlling for sibsize eliminates or reverses this correlation.

We show in Table A.17 that the magnitude and sign of JP's coefficient of interest is not robust to respecifications to functional forms that JP uses elsewhere in its analysis. Perhaps most notably, Table A.17 shows that JP's completed fertility result is sensitive to removing multiple births from the sample, such as twins or triplets. Although JP includes these observations, other studies of birth order — such as Black et al. (2005), Buckles and Munnich (2012), and Lehmann et al. (2016) — do not (see footnote [4] on page 7).[27]

Many of the children in JP's "completed fertility" subsample in fact have mothers who are at risk of pregnancy. After dropping the multiple births (twins, triplets, as described above), there are 41,862 children in the Indian data whose heights were measured and whose mother answered the desired fertility question in the DHS. Of these, 68% (28,449) have a mother who JP classify as likely to have completed fertility. Of these, 69% (19,537) are so classified by JP because they report wanting no more children. However, of the 19,537, only 25% are using modern contraception. 62% of the 19,537 women who want no more children report using no contraceptive technique whatsoever. This is not because they are infecund: 85% of these 62% are less than 35 years old.

In Figure A.4 and Table A.15, we saw that the completed fertility subsample shows the same pattern as the main height sample: at the same sibsize, later birth order children in India are at least as tall as earlier birth-order children. JP reports a robustness check in column 4 of its Table 2 in which it restricts the sample to its "completed fertility" subsample, and in which JP includes a number of controls, including sibsize × India controls. This is the only child height regression with JP's DHS data in which JP controls for sibsize. In this section, we consider whether this result is informative about the effect of birth order on child height in India. First, we show that the completed-fertility subsamples of India and SSA are demographically different from the main height sample and from one another. Second, we replicate JP's regression on this subsample and show that it is sensitive to functional form, and especially to JP's inclusion of multiple births.

Table A.16 compares the completed-fertility subsample with the main height sample, separately

India). One reason that sibsize is correlated with socioeconomic status is heterogeneous risk of unwanted pregnancy. In other studies of birth order, "completed fertility" is identified by including only mothers whose last birth was at least, for example, five years before the survey (compare Price, 2008); this strategy is not available to JP, because none of these children have measured height.

[27]Because India and SSA are at different points in the fertility transition, the completed fertility subsample cuts from the Indian and SSA data in very different ways. 68% of children in the Indian main height sample are in the completed fertility sample, while only 31% of children in the SSA main height sample are in the completed fertility sample. The average mother in SSA who reports not wanting more children is much older than the average Indian mother who does not want more children, and has several more children. One consequence is that mothers in SSA who report not wanting children are especially likely to have had a multiple birth, such as twins or triplets: in the completed fertility subsample of SSA children, 3.7% have a mother who has had a multiple birth, compared with 1.4% in the Indian completed fertility sample and less than 1% in the rest of the Indian main height sample.

in India and SSA. The table shows that the completed-fertility cut acts differently in the two samples. Again, this is because India and SSA are at different places in the fertility transition: it is common to express a desire for no more children in India; it is uncommon in SSA. As a result, India is 25% of the main height sample and 42% of the completed-fertility subsample. 20% of children in the Indian main height sample have a mother who has been sterilized, compared with less than one percent in SSA. The average child in SSA in the completed-fertility sample was born when his or her mother was over 30 years old and comes from a sibsize of over 5; the average child in India in the main height sample but not in the completed fertility sample was born when his or her mother was less than 23 years old and comes from a sibsize of 2.

Table A.17 presents JP's regression result in the completed-fertility subsample.[28] Unlike all other results in this paper (except for Table A.18, which is a robustness check of our main results in this sample), this table follows JP in including multiple births in the sample. Panel A preserves JP's numbering of birth order from 1; Panel B replicates Table 3's numbering of birth order from the last. In its estimate with the completed-fertility subsample, JP preserves its top coding of birth order at "3 or more." 78% of SSA observations in the completed fertility subsample are third-born or later, and 65% are later-than-third born. A larger fraction of the SSA completed fertilty sample is fifth-born than is either first or second-born.

In Panel B, as in Table 3, the India × later-born coefficient is positive in each case. In Panel A, column 1 is our implementation of the specification JP presents in its table[29] Moving from column 1 to column 2 removes children from multiple births (twins, triplets). These are selected for in the completed-fertility subsample, because mothers in SSA are generally unlikely to say they do not want more children, but are more likely to in the minority of cases who have had multiple births. JP's "completed fertility" result is sensitive to the inclusion of these observations.

Moving from column 2 to column 3 removes the control for the mother's age at the child's birth; this change is sufficient for the interaction coefficient to change from negative to essentially zero. Mother's age at child birth is well predicted by an India indicator in the completed fertility subsample: among these observations, the Indian median is about the 25th percentile in the SSA distribution, and the SSA median is the 80th percentile in the Indian distribution. In the remaining columns, the coefficient on India × third-born is positive.

Column 7 returns to the main height sample for a robustness check. JP notes a concern that perhaps sibsize is differently correlated with child height in the main height sample than in the completed-fertility subsample. Column 7 — which controls for triply interacted fixed effects for sibsize × India × an indicator for the completed-fertility subsample — demonstrates that our main result is not sensitive to this concern.

[28] The sample size varies across columns due to the presence of the controls that JP uses.

[29] We suspect that the quantitative difference may be because for some survey rounds, JP uses a different literacy variable than the birth recode's v155, in addition to using a differently constructed measure of mothers' age. Moving across columns to the right removes in steps the controls that JP uses.

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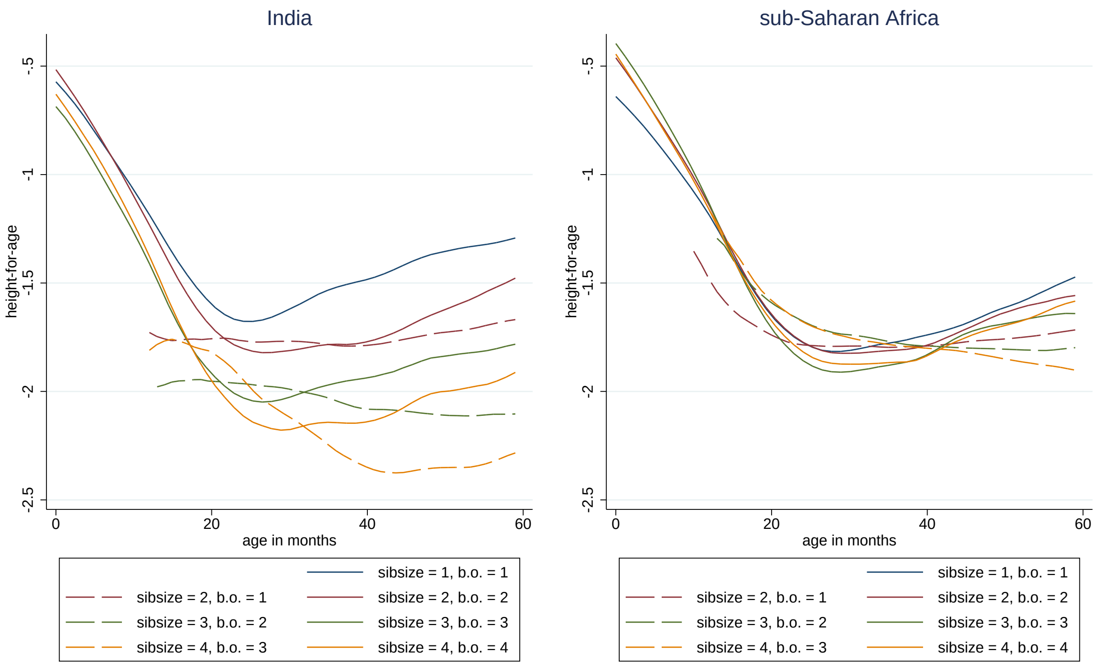
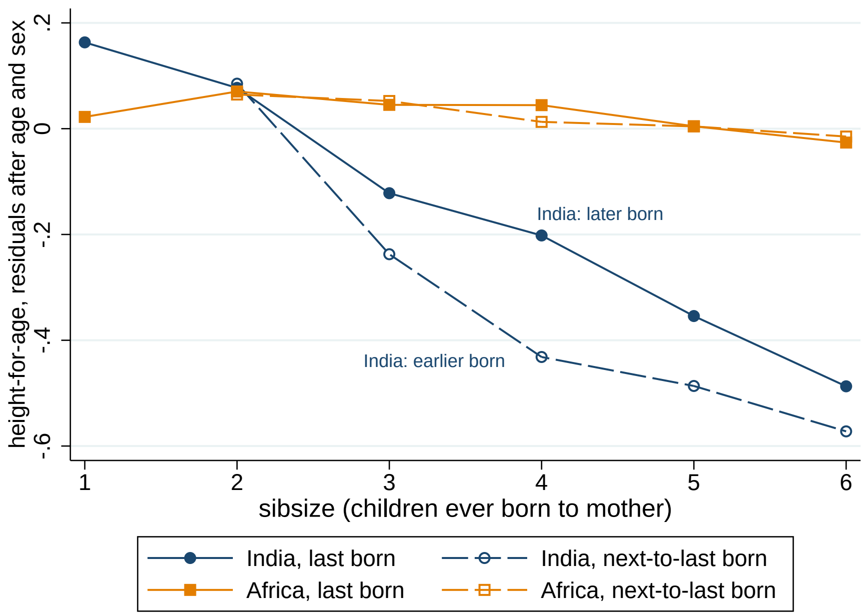
Figure A.1: HAZ by birth order and sibsize in India and sub-Saharan Africa, locally weighted regressions by age



Note: The India panel of Figure A.1 shows large level differences between local polynomial regressions of different colors indicating that higher-sibsize children are shorter than children from lower sibsizes at the same age. This pattern is considerably dampened in the SSA data. Further, the India panel suggests that once children are more than two years old and have exited the critical period for stunting, later-born children appear taller relative to a healthy population, on average, than earlier-born children of the same age. The local polynomial regressions for second-to-last birth order children begin around 18 months because, by definition, second-to-last birth order children require there to be a younger sibling, the last birth order child. See also Cummins (2013). This figure is computed using the main height sample.

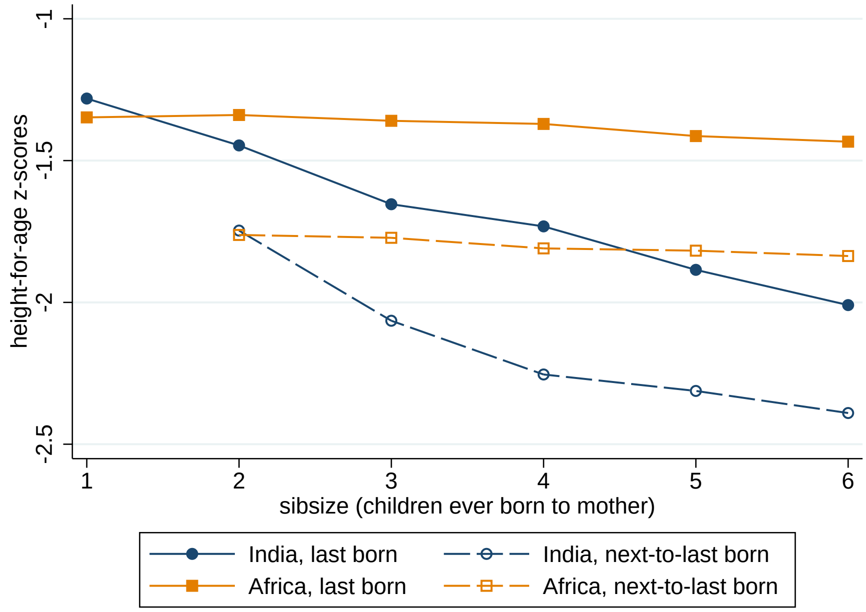
Figure A.2: HAZ by **sibsize**: Comparing birth orders at a sibsize reverses India's birth order-height correlation.



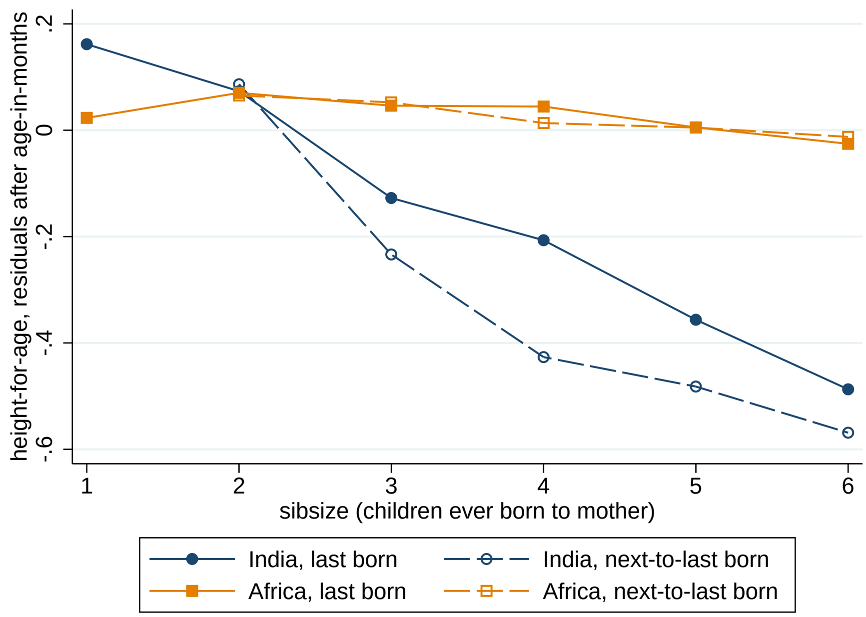
Note: This is an alternative presentation of the information in Panel (c) of Figure 3, drawn to visually resemble Panel (c) of Figure 1. Note that the horizontal axis of this figure is *sibsize* and the horizontal axis of Panel (c) of Figure 1 is the child's birth order.

Figure A.3: Robustness of Figure A.2 to alternative residualization

Panel A: no residualization: vertical axis is raw HAZ

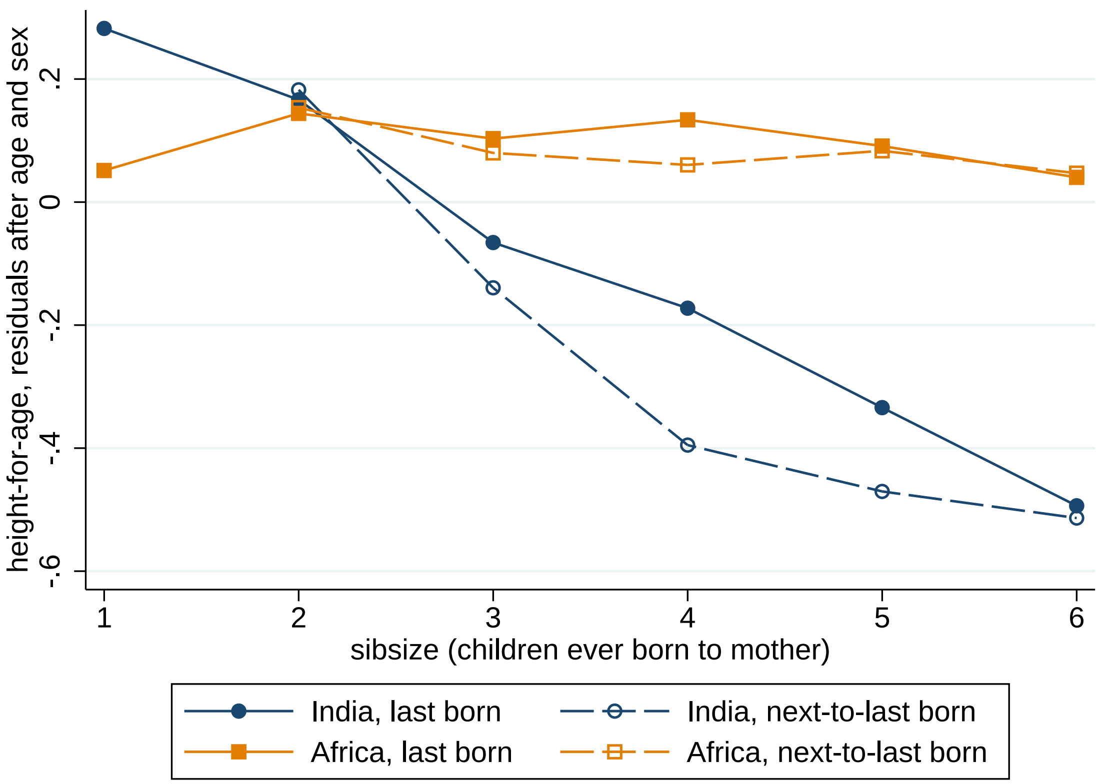


Panel B: age residualization: vertical axis is HAZ residuals after 60 age-in-months controls



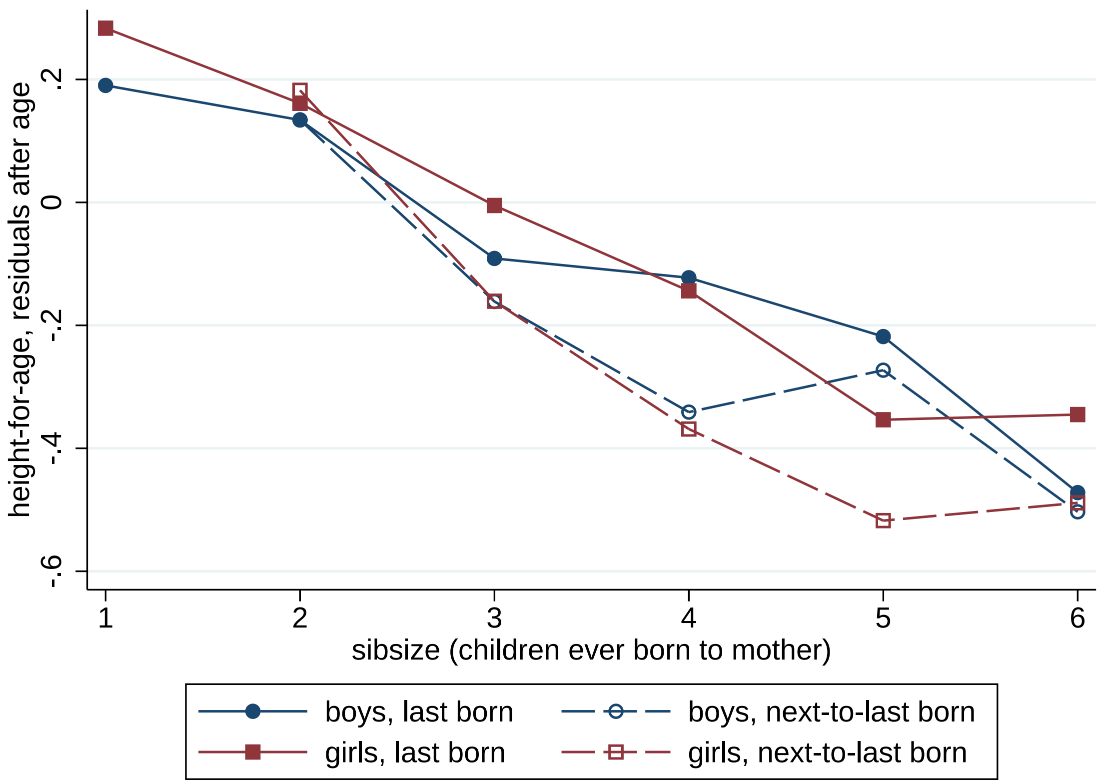
Note: Compare with Figure A.2; Figure A.2 residualizes out age-in-months by sex; this figure does not. In Panel A of this figure, last-born children appear much taller than next-to-last born children due to the fact that average HAZ decreases in age in these populations, as seen is Figure A.1.

Figure A.4: HAZ by birth order and sibsize in India and sub-Saharan Africa restricted to JP's "completed fertility" subsample, residuals after age and sex



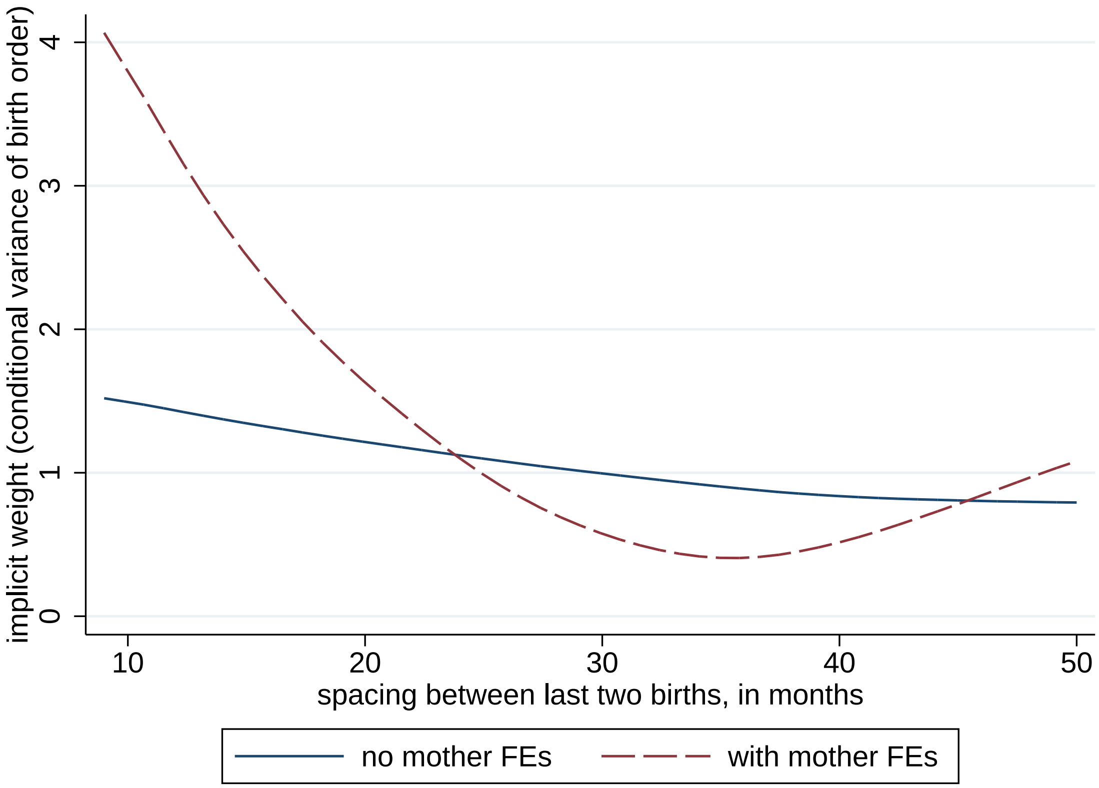
Note: Compare with Figure A.2. The figure is computed in the same way, except that only children in JP's "completed fertility" subsample are included in the figure.

Figure A.5: HAZ by birth order and sibsize in India, by child sex



Note: Compare with Figure A.2. The figure is computed in the same way, except that only Indian children are included, and gradients are plotted separately for boys and girls. See section 3 of the text.

Figure A.6: Implicit regression weighting is greater at shorter birth spacing, especially with mother fixed effects



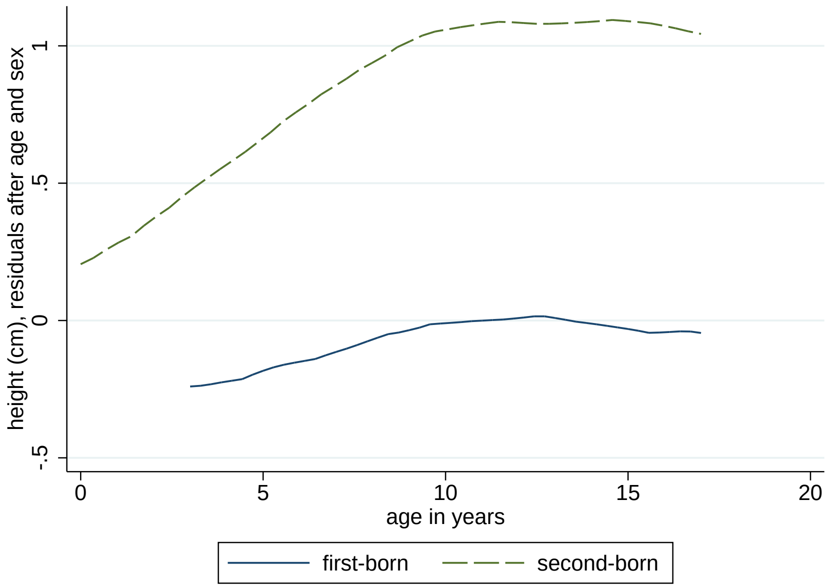
Note: This figure is generated by the following procedure, using all observations in the main height sample from a sibsize of three who are either second or third birth order:

1. Regress an indicator for "birth order of 3" on the 120 age-in-months by sex dummies.
2. Predict the residual for the observations included in that regression.
3. Square the predicted residual.
4. Normalize the squared predicted residuals by dividing by their mean.
5. Plot the normalized, squared predicted residuals as the vertical axis in a locally weighted regression, against the spacing in months between the second-born and third-born children as the horizontal axis.
6. Repeat this procedure, including mother fixed effects in the regression in step 1.

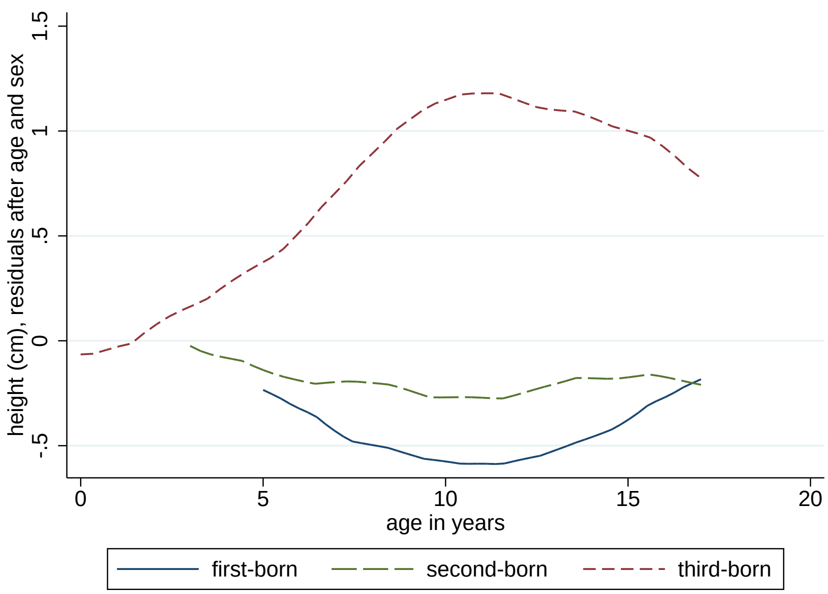
The result demonstrates that the variance in birth order conditional on age-in-months is predictable by birth spacing, especially when mother fixed effects are used. This will effectively weight the regression results, in the sense of Angrist (1998), such that the weighted average treatment effect resembles the effect of birth order where birth spacing is very low.

Figure A.7: Replication of main result in India Human Development Survey (IHDS)

Panel (a): Children in sibsize of 2



Panel (b): Children in sibsize of 3



Note: Data are from the most recent (2012) round of the IHDS. Because age-in-months is not uniformly available across all observations, instead of height-for-age z-scores, here the dependent variable is height in centimeters, residualized after sex × age-in-years indicators. Regression results available upon request replicate in the IHDS the pattern of Table 2, using height in centimeters and the log of height in centimeters as dependent variables.

Table A.1: The average child with measured height is older in India than in SSA, by different amounts at different sibsizes and in the mother-fixed-effects subsample

	(1)	(2)	(3)	(4)	(5)	(6)
dependent variable:	months between child's birth and survey (age)				HAZ	
sample:	full	with height	with height	with 2 heights	with height	with height
birth:	< 60 months	< 60 months	< 60 months	< 60 months	< 60 months	< 24 months
India	1.235***	1.976***	3.011***	0.835***		
	(0.0723)	(0.0847)	(0.0871)	(0.110)		
sibsize FEs			$F = 1,803$			
			$p < 0.0001$			
months since birth					-0.0221***	-0.0980***
					(0.000290)	(0.00120)
constant	28.60***	27.91***	19.59***	29.26***	-0.913***	-0.0453**
	(0.0324)	(0.0426)	(0.0987)	(0.0499)	(0.0113)	(0.0171)
n (births)	240,705	166,153	166,153	71,934	166,153	70,427

Note: Months since birth is what a child's age would be if it were alive at the time of the survey. The "< 60 months" sample is the set of children who would have been young enough to have their height measured if they survived to the time of the survey. Standard errors clustered by survey PSU in parentheses. "with 2 heights" means two heights per mother, so fixed effects are possible.

Table A.2: Higher sibsize predicts worse household contexts by more in India than in SSA(full sample from birth history)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
dependent variable:	mother's height		mother's BMI		mother is literate		household urban	
sibsize of 2 × India	0.105	0.0413	0.245***	0.0222	0.0134*	-0.00181	0.0184**	0.00202
	(0.0916)	(0.0915)	(0.0603)	(0.0569)	(0.00642)	(0.00632)	(0.00699)	(0.00683)
sibsize of 3 × India	-0.476***	-0.532***	-0.328***	-0.523***	-0.124***	-0.137***	-0.0126	-0.0266***
	(0.0968)	(0.0966)	(0.0669)	(0.0627)	(0.00707)	(0.00700)	(0.00787)	(0.00768)
sibsize of 4 × India	-1.008***	-1.033***	-0.794***	-0.879***	-0.216***	-0.222***	-0.0216*	-0.0277**
	(0.107)	(0.107)	(0.0760)	(0.0715)	(0.00781)	(0.00772)	(0.00921)	(0.00897)
India	-5.639***	-5.801***	-1.233***	-1.792***	0.137***	0.102***	0.0995***	0.0613***
	(0.0832)	(0.0834)	(0.0577)	(0.0516)	(0.00718)	(0.00690)	(0.0114)	(0.0110)
sibsize of 2	0.154*	0.00570	0.424***	-0.0896*	-0.0506***	-0.0842***	-0.0261***	-0.0625***
	(0.0645)	(0.0650)	(0.0374)	(0.0365)	(0.00384)	(0.00387)	(0.00380)	(0.00388)
sibsize of 3	0.258***	-0.0170	0.627***	-0.326***	-0.103***	-0.165***	-0.0626***	-0.130***
	(0.0677)	(0.0699)	(0.0406)	(0.0404)	(0.00406)	(0.00426)	(0.00403)	(0.00444)
sibsize of 4	0.423***	0.0391	0.732***	-0.599***	-0.152***	-0.239***	-0.0962***	-0.191***
	(0.0721)	(0.0771)	(0.0451)	(0.0467)	(0.00439)	(0.00479)	(0.00442)	(0.00523)
mom's birth cohort		-0.00376***		-0.0131***		-0.000865***		-0.000936***
		(0.000247)		(0.000186)		(0.0000195)		(0.0000239)
constant	157.9***	161.6***	22.56***	35.48***	0.560***	1.413***	0.406***	1.330***
	(0.0549)	(0.251)	(0.0301)	(0.191)	(0.00438)	(0.0198)	(0.00586)	(0.0250)
n (all births)	377,180	377,180	376,266	376,266	443,712	443,712	447,073	447,073

Note: Observations are children, although the dependent variables are properties of their mothers. Each of these dependent variables is constant across birth orders within a set of siblings, because they are properties of households or mothers. Mother's height (in cm) and body mass index (BMI) are as measured at the time of the DHS survey. All births up to sibsizes of 4 are included in the sample, whether or not height is measured, so the sample size is larger than in the height results; see Table A.3 for a replication with the measured-height subsample. Mother's birth cohort is the century-month code (CMC) of her month of birth, entered linearly. Standard errors are clustered by survey PSU.

Table A.3: Higher sibsize predicts worse household contexts by more in India than in SSA(main height sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
dependent variable:	mother's height		mother's BMI		mother is literate		household urban	
sibsize of 2 × India	-0.102	-0.0256	-0.284***	-0.176**	0.00878	0.0243**	0.0101	0.0216*
	(0.122)	(0.121)	(0.0699)	(0.0677)	(0.00906)	(0.00879)	(0.00958)	(0.00942)
sibsize of 3 × India	-0.768***	-0.544***	-0.951***	-0.634***	-0.120***	-0.0740***	-0.0582***	-0.0244*
	(0.137)	(0.137)	(0.0785)	(0.0763)	(0.0108)	(0.0106)	(0.0114)	(0.0112)
sibsize of 4 × India	-1.390***	-1.097***	-1.200***	-0.787***	-0.205***	-0.145***	-0.0486***	-0.00461
	(0.159)	(0.159)	(0.0924)	(0.0909)	(0.0123)	(0.0121)	(0.0138)	(0.0137)
India	-5.483***	-5.759***	-1.341***	-1.732***	0.147***	0.0902***	0.0847***	0.0433***
	(0.0986)	(0.0991)	(0.0574)	(0.0546)	(0.00834)	(0.00793)	(0.0123)	(0.0120)
sibsize of 2	0.0962	-0.198*	0.282***	-0.134**	-0.0718***	-0.132***	-0.0351***	-0.0793***
	(0.0809)	(0.0823)	(0.0412)	(0.0414)	(0.00559)	(0.00561)	(0.00541)	(0.00558)
sibsize of 3	0.286***	-0.291**	0.489***	-0.328***	-0.132***	-0.250***	-0.0611***	-0.148***
	(0.0858)	(0.0919)	(0.0458)	(0.0482)	(0.00599)	(0.00636)	(0.00582)	(0.00660)
sibsize of 4	0.529***	-0.314**	0.592***	-0.601***	-0.187***	-0.359***	-0.0960***	-0.223***
	(0.0942)	(0.106)	(0.0495)	(0.0563)	(0.00627)	(0.00707)	(0.00623)	(0.00798)
mother's birth cohort		-0.00943***		-0.0133***		-0.00193***		-0.00142***
		(0.000504)		(0.000299)		(0.0000379)		(0.0000466)
constant	157.8***	167.4***	21.99***	35.56***	0.565***	2.530***	0.367***	1.808***
	(0.0654)	(0.518)	(0.0314)	(0.310)	(0.00531)	(0.0386)	(0.00659)	(0.0484)
n (height subsample)	114,005	114,005	113,748	113,748	113,977	113,977	114,750	114,750

Note: Observations are children, although the dependent variables are properties of their mothers. Each of these dependent variables is constant across birth orders within a set of siblings, because they are properties of households or mothers. Mother's height (in cm) and body mass index (BMI) are as measured at the time of the DHS survey. Only births with measured height are included; see Table A.2 for all births. Mother's birth cohort is the century-month code (CMC) of her month of birth, entered linearly. Standard errors are clustered by survey PSU.

Table A.4: Replication of Table 2 only including children at least 24 months old

	(1)	(2)	(3)	(4)	(5)	(6)
sample:	India & sub-Saharan Africa		India only		sub-Saharan Africa only	
India	0.109***	0.259***				
	(0.0249)	(0.0363)				
2nd born × India	-0.180***	0.0346				
	(0.0308)	(0.0372)				
3rd born × India	-0.322***	0.179**				
	(0.0371)	(0.0576)				
4th born × India	-0.433***	0.244**				
	(0.0426)	(0.0787)				
2nd born	-0.00857	-0.0129	-0.190***	0.0209	-0.00804	-0.0137
	(0.0195)	(0.0252)	(0.0238)	(0.0284)	(0.0195)	(0.0256)
3rd born	-0.0728***	-0.126***	-0.399***	0.0453	-0.0736***	-0.130***
	(0.0213)	(0.0377)	(0.0304)	(0.0466)	(0.0213)	(0.0388)
4th born	-0.0681**	-0.157**	-0.504***	0.0771	-0.0686**	-0.163**
	(0.0230)	(0.0494)	(0.0360)	(0.0663)	(0.0230)	(0.0512)
sibsize indicators		$F = 17$		$F = 26$		$F = 4.3$
		$p < 0.0001$		$p < 0.0001$		$p = 0.0002$
n (children over 24 mos.)	69,413	69,413	22,028	22,028	47,385	47,385

Note: In all columns the dependent variable is the child's height-for-age z-score. The purpose of this table is to verify that our main result — the effect on the birth order × India interaction of controlling for sibsize and sibsize × India — does not depend upon the correlation between height-for-age and child age-in-months, because this correlation is absent or considerably dampened above age two.

In all columns 1-6 age is controlled as a set of age-in-months × sex indicators, which is the resolution at which the height-for-age reference tables are defined. Sibsize indicators are a set of all available sibsize indicators and are interacted with an India indicator in the first two columns; F-tests report tests that these indicators jointly improve the fit of the model. No further controls are included. Standard errors are clustered by survey PSU.

Table A.5: Mother-fixed-effects results are fragile

	(JP)	(1)	(2)	(3)	(4)	(5)
birth orders:	[Table 2, column 5]	all available		last and next-to-last born only		
India × 2nd born	-0.243	-0.261	-0.052			
	(0.048)	(0.048)	(0.036)			
India × 3rd+ born	-0.436	-0.425	0.001			
	(0.085)	(0.086)	(0.058)			
2nd born	-0.167	-0.180	-0.216			
	(0.027)	(0.027)	(0.027)			
3rd+ born	-0.334	-0.369	-0.442			
	(0.044)	(0.043)	(0.042)			
India × last born				0.230	0.148	0.0965
				(0.0837)	(0.0260)	(0.0276)
last born				-1.320	-1.297	-1.342
				(0.0518)	(0.0432)	(0.0440)
age FEs			✓		✓	
age × India FEs	✓	✓		✓		
age (months, linear)						-0.0637
						(0.00140)
mother FEs	✓	✓	✓	✓	✓	✓
n	83,228	80,785	80,785	74,762	74,762	74,762

Note: In all columns the dependent variable is the child's height-for-age z-score. The column marked JP reprints results from the published paper; the rest of the columns are our analysis. In columns 1 and 3, age is controlled as a set of age-in-months indicators interacted with an India indicator (as in JP's mother-fixed-effect result reprinted in this table). In columns 2 and 4, the age indicators are not interacted with an India indicator (as in JP's main result, reprinted in this paper in Table 2). In column 5, age-in-months is controlled linearly. Columns 3, 4, and 5 omit the 7.5% of the mother-fixed-effects subsample that are not the last or next-to-last born child of their sibship at the time of the survey. Standard errors are clustered by survey PSU.

Table A.6: Fixed effect results depend on functional form, further details part 1: The India × birth order interaction depends on how age is controlled and how birth order is coded

	(JP)	(1)	(2)	(3)	(4)	(5)
mother FEs	yes	yes	yes	yes	yes	yes
age × sex × India FEs	no	yes	no	no	no	no
age × India FEs	yes	no	yes	no	no	no
full-sample age × India residualization	no	no	no	yes	no	no
age FEs	no	no	no	no	yes	no
age × sex FEs	no	no	no	no	no	yes
Panel A: All birth orders, coded 3+ as in JP						
2nd born × India	-0.243	-0.256***	-0.261***	-0.0751*	-0.0515	-0.0437
	(0.048)	(0.0480)	(0.0481)	(0.0365)	(0.0364)	(0.0365)
3rd+ born × India	-0.436	-0.422***	-0.425***	-0.0536	0.00142	0.0176
	(0.085)	(0.0858)	(0.0861)	(0.0576)	(0.0576)	(0.0577)
2nd born	-0.167	-0.183***	-0.180***	-0.119***	-0.216***	-0.219***
	(0.027)	(0.0271)	(0.0272)	(0.0240)	(0.0267)	(0.0267)
3rd+ born	-0.334	-0.370***	-0.369***	-0.242***	-0.442***	-0.445***
	(0.044)	(0.0432)	(0.0433)	(0.0350)	(0.0421)	(0.0421)
n	83,228	80,785	80,785	80,785	80,785	80,785
Panel B: Only last and next-to-last births in sibships with two measured heights						
last born × India		0.174*	0.160†	-0.0152	0.107***	0.115***
		(0.0835)	(0.0830)	(0.0262)	(0.0264)	(0.0264)
last born		-1.146***	-1.153***	-0.0581***	-1.139***	-1.132***
		(0.0518)	(0.0518)	(0.0139)	(0.0430)	(0.0430)
n		71,934	71,934	71,934	71,934	71,934

Note: In all columns the dependent variable is the child's height-for-age z-score. The JP column retypes column 5 of Table 2 of the published paper. Standard errors are clustered by survey PSU.

Observation: We highlight the difference in results between column 2, which controls for age × sex × India indicators, and column 5, which controls for age × sex indicators without the interaction with India. More generally, we show various methods of controlling for age, because that is an important way in which the fixed effects specification is sensitive; we tend to find that interacting age with India makes a difference, but interacting age with child sex does not, suggesting child sex is not an important control in this case.

Column 3: "Full-sample age × India residualization" regressions use as dependent variables residuals after HAZ is regressed only on the set of age × India fixed effects used in column 1, in a regression with the main height sample (i.e., including children who are not in the mother-fixed-effects subsample because they do not have a measured sibling). This preserves the age patterns being controlled in the main height sample. This eliminates one difference between the main height sample and the fixed effects subsample — namely, the different age pattern — and the interaction coefficients become small and in one case lose statistical significance; other concerns about mother fixed effects, however, may still remain in this specification.

Table A.7: Because birth spacing interacts with birth order, mother fixed effects is misspecified for height in the DHS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
sibsizes included:	1 and 2	2 only	2 only	2 only	2 only	2 only	2 only
heights per mom:	1 or 2	1 or 2	1 or 2	2 only	2 only	2 only	2 only
mother FEs:	no	no	no	no	no	yes	yes
Panel A: India, 1st born and 2nd born children only							
2nd born	-0.0486*	0.0470	0.137***	-0.263***	0.122	-0.882***	1.516*
	(0.0213)	(0.0301)	(0.0348)	(0.0609)	(0.0861)	(0.0904)	(0.641)
2nd born × birth			0.0268***		0.0318***		0.0736***
spacing (demeaned)			(0.00250)		(0.00399)		(0.0195)
birth spacing			-0.0191***		-0.0227***		
(demeaned)			(0.00246)		(0.00281)		
age bins × sex	✓	✓	✓	✓	✓	✓	✓
n	22,151	13,471	13,471	7,540	7,540	7,540	7,540
Panel B: Sub-Saharan Africa, 1st born and 2nd born children only							
2nd born	0.0536**	0.0313	0.128***	-0.262***	0.122	-0.835***	1.702**
	(0.0181)	(0.0305)	(0.0347)	(0.0703)	(0.0924)	(0.0980)	(0.564)
2nd born × birth			0.0227***		0.0295***		0.0729***
spacing (demeaned)			(0.00241)		(0.00375)		(0.0161)
birth spacing			-0.0180***		-0.0217***		
(demeaned)			(0.00241)		(0.00269)		
age bins × sex	✓	✓	✓	✓	✓	✓	✓
n	41,088	23,675	23,675	12,834	12,834	12,834	12,834

Note: In all columns the dependent variable is the child's height-for-age z-score. Section B walks the reader through this result, which progressively builds a mother-fixed-effects specification across columns:

1. This column is most like JP's main result, reprinted in Table 2: It mixes sibsizes 1 and 2 and mothers with only one and more than one measured child. Therefore, all of the second-borns are from sibsizes of 2, while first-borns are from sibsize of 1 or 2.
2. This column "controls" for sibsize by including only children of sibsize 2; it still has children of mothers with 1 or more than 1 measured child.
3. Preserving the sample of column 2, this column shows that birth spacing interacts with birth order to predict height-for-age.
4. Relative to column 2, column 4 restricts the sample to a fixed effects subsample by excluding children without a measured sibling.
5. Using the sample of column 5, this column estimates the same specification as column 3, preserving the larger sample's demeaning. Notice the similarity with the regression coefficients in column 3, which suggests that columns 2 and 4 differ because the *same* relationship among birth spacing, birth order, and height is estimated on a *different* distribution of birth spacing.
6. Preserving the same matched-pair sample and independent variable as column 4, column 6 adds mother fixed effects; the coefficient becomes much larger in absolute value.
7. With the same sample and variables as in column 5, the interactive slope is much steeper with mother fixed effects.

Table A.8 replicates this table with birth orders 2 and 3 rather than birth orders 1 and 2. Standard errors are clustered by survey PSU.

Table A.8: Robustness check of Table A.7 using birth orders 2 and 3 rather than 1 and 2

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
sibsizes included:	2 and 3	3 only	3 only	3 only	3 only	3 only	3 only
heights per mom:	1 or 2	1 or 2	1 or 2	2 only	2 only	2 only	2 only
mother FEs:	no	no	no	no	no	yes	yes
Panel A: India, 2nd and 3rd born children only							
3rd born	-0.138***	0.115*	0.219***	-0.440***	-0.0767	-1.123***	1.084
	(0.0276)	(0.0446)	(0.0504)	(0.103)	(0.136)	(0.152)	(1.057)
3rd born × birth			0.0353***		0.0333***		0.0686*
spacing (demeaned)			(0.00388)		(0.00634)		(0.0327)
birth spacing			-0.0275***		-0.0254***		
(demeaned)			(0.00383)		(0.00427)		
age bins × sex							
n	16,325	7,021	7,021	3,602	3,602	3,602	3,602
Panel B: Sub-Saharan Africa, 2nd and 3rd born children only							
3rd born	-0.0196	-0.0425	0.0538	-0.466***	-0.139	-0.975***	1.660*
	(0.0200)	(0.0356)	(0.0381)	(0.0908)	(0.112)	(0.124)	(0.660)
3rd born × birth			0.0320***		0.0287***		0.0775***
spacing (demeaned)			(0.00276)		(0.00445)		(0.0192)
birth spacing			-0.0261***		-0.0268***		
(demeaned)			(0.00274)		(0.00294)		
age bins × sex							
n	35,516	18,985	18,985	10,262	10,262	10,262	10,262

Note: See the note on the prior page to Table A.7; this table replicates it, except that where Table A.7 concentrates on sibsizes of 2, this table concentrates on sibsizes of 3.

Table A.9: Birth spacing is lower among the subsample with two measured heights per mother (the mother-fixed-effects subsample) than in the main height sample

	(1)	(2)	(3)	(4)
birth orders:	2nd+	2nd+	2nd+	2nd+
sample:	all births	measured height	measured height	measured height
region:	India & SSA	India & SSA	India	SSA
height measured	5.689***			
	(0.0764)			
multiple sibling heights per mom		-16.78***	-17.09***	-16.78***
		(0.134)	(0.252)	(0.156)
constant	33.09***	47.98***	45.67***	48.71***
	(0.0452)	(0.129)	(0.234)	(0.153)
n (2nd and later births)	705,695	125,465	28,438	97,027

Note: The dependent variable is birth spacing, defined as the century-month code of a birth minus the century-month code of the mother's prior birth. This definition necessarily excludes first-born children. "Height measured" is an indicator that the birth observation contains a measured height. "Multiple sibling heights per mom" is an indicator that the child is one of a set of *more than one* sibling with measured height. Standard errors are clustered by survey PSU.

Table A.10: Households and mothers are more disadvantaged in the mother-fixed-effects subsample than in the main height sample, especially in India

	India & SSA		India only		SSA only	
sample:	main height	mother FE	main height	mother FE	main height	mother FE
child's HAZ	-1.54	-1.59	-1.66	-1.78	-1.50	-1.53
mother's height (cm)	156.59	156.72	151.90	151.87	158.18	158.19
mother's BMI	21.88	21.69	20.35	20.03	22.40	22.19
mother literate	0.43	0.38	0.51	0.46	0.40	0.35
household urban	0.30	0.27	0.37	0.33	0.28	0.25
n	166,153	71,934	41,972	16,754	124,181	55,180

Note: This table presents sample means of the same variables included in Tables A.2 and A.3. The mother-fixed-effects subsample is the subsample of children with measured height who also have another sibling with measured height.

Comment: The 0.2 difference in HAZ between Indian children in the mother FE sample and not in the mother FE sample (within the main height sample) is even larger than the India-SSA difference which motivates JP's analysis.

Table A.11: In the mother-fixed-effects subsample, birth spacing is lower in India than in sub-Saharan Africa

dependent variable:	(1) spacing	(2) spacing	(3) spacing	(4) spacing
India	-3.341***	-3.043***	-3.006***	-2.852***
	(0.123)	(0.120)	(0.124)	(0.118)
sibsize indicators			$F = 37$	$F = 127$
			$p < 0.0001$	$p < 0.0001$
mother's age at birth				0.736***
				(0.0163)
n (births in mother FE sub-sample)	68,837	68,837	68,837	68,837

Note: The dependent variable is birth spacing, defined as the century-month code of a birth minus the century-month code of the mother's prior birth. This definition necessarily excludes first-born children. A child is included in this sample only if the child is one of a set of *more than one* sibling with measured height. Standard errors are clustered by survey PSU.

Table A.12: Low birth spacing has more severe consequences for child height where maternal nutrition is poor; maternal nutrition is worse in India than in sub-Saharan Africa

	(1)	(2)	(3)	(4)	(5)
dependent variable:	mother's BMI	mother's BMI	child's HAZ	child's HAZ	child's HAZ
sample:	height observed	height & spacing	height & spacing	height & spacing	height & spacing
India	-2.036***	-2.218***			
	(0.0399)	(0.0432)			
spacing			0.00638***	0.00555***	0.00541***
			(0.000251)	(0.000242)	(0.000242)
mother's BMI (de-meaned)			0.0616***	0.0596***	0.0611***
			(0.00275)	(0.00266)	(0.00267)
spacing × BMI			-0.000206***	-0.000125*	-0.000146**
			(0.0000504)	(0.0000486)	(0.0000487)
age-by-sex FEs				✓	✓
sibsize FEs					✓
constant	-0.0878***	0.0174	-1.788***	-1.756***	-1.661***
	(0.0229)	(0.0251)	(0.0126)	(0.0122)	(0.0155)
n (births)	164,586	124,265	124,265	124,265	124,265

Note: This table documents an additional reason to be concerned about using mother fixed effects on the height sample: birth spacing is most important for predicting child outcomes where maternal nutrition is poor, and maternal nutrition is worse in India than in sub-Saharan Africa. "Height & spacing" means that the sample is limited to births in which both child height and birth spacing are observed. "India" is an indicator that the child is from India rather than sub-Saharan Africa. Standard errors are clustered by survey PSU.
We highlight that BMI is measured, like every other anthropometric measurement in the DHS, at the time of the survey. It is constant across siblings, because each mother is only measured once. This is not ideal, if the goal is to learn about early life heath: a better measure would combine maternal nutrition immediately before pregnancy with weight gain during pregnancy. Later-life BMI at the time of the survey is correlated with error with these ideal measures. This issue is discussed in more depth in Coffey and Spears (2019).

Table A.13: JP's Hindu-Muslim robustness check is not robust to controlling for sibsize: Higher sibsize Hindu children in India are more disadvantaged than higher sibsize Muslim children in India

	(1)	(2)	(3)
dependent variable:	child's HAZ	child's HAZ	mother's BMI
2nd born	-0.0980	-0.00665	
	(0.0522)	(0.0613)	
3rd+ born	-0.351***	0.0848	
	(0.0500)	(0.0917)	
Hindu	0.0952*	0.128*	-0.310*
	(0.0448)	(0.0581)	(0.148)
Hindu × 2nd born	-0.0363	0.0264	
	(0.0564)	(0.0669)	
Hindu × 3rd+ born	-0.155**	0.0245	
	(0.0552)	(0.0996)	
Hindu × all sibsizes		✓	
sibsize of 2			-0.0157
			(0.172)
sibsize of 3			-0.415*
			(0.182)
sibsize of 4			-0.345
			(0.212)
sibsize of 5			-0.641**
			(0.228)
Hindu × sibsize of 2			-0.120
			(0.183)
Hindu × sibsize of 3			-0.354
			(0.194)
Hindu × sibsize of 4			-0.680**
			(0.227)
Hindu × sibsize of 5			-0.767**
			(0.246)
n	35,358	35,358	31,951
sibsizes included:	all	all	≤ 5

Note: Data are all Hindu or Muslim children with measured height in India's 2005-6 DHS (NFHS-3), the same survey round from which the child-level data in the main result is taken. The average Hindu child with measured height comes from a sibsize of 2.8; the average Muslim child with measured height comes from a sibsize of 3.5. 69% of children with meaured height are Hindu; 16% are Muslim. Compare with JP's Table 4. BMI = body mass index; mother's BMI is measured at the time of the survey, so it is constant for all observations of children born to a mother. Standard errors clustered by PSU.

Table A.14: There is no evidence of a special advantage of first-borns or first-born boys in India, focusing on sibsizes of 2

	(1)	(2)	(3)	(4)
sample:	main	mother FE	main	mother FE
age × sex controls:	no interaction	no interaction	India interaction	India interaction
sibsize included:	2 only	2 only	2 only	2 only
Panel A: Comparing first-borns with second-borns				
India	0.0180	0.0110		
	(0.0332)	(0.0349)		
2nd born	0.0507†	-0.241***	0.0304	-0.275***
	(0.0281)	(0.0502)	(0.0307)	(0.0625)
India × 2nd born	-0.0243	-0.0577	0.0188	0.00311
	(0.0402)	(0.0495)	(0.0475)	(0.0918)
n	37,146	20,374	37,146	20,374
Panel B: Comparing "first-born boys" with "girls and second-borns"				
India	-0.00746	-0.0362		
	(0.0203)	(0.0286)		
first born boy	-0.0869*	0.251***	-0.0271	0.316***
	(0.0378)	(0.0674)	(0.0430)	(0.0876)
India × first born boy	0.0534	0.0740	-0.0805	-0.0713
	(0.0511)	(0.0569)	(0.0657)	(0.127)
n	37,146	20,374	37,146	20,374

Note: In all columns the dependent variable is the child's height-for-age z-score. This table focuses on sibsizes of 2 because over 90% of children are of birth order 2, among those who have measured height and who have a first-born sibling with measured height. Standard errors are clustered by survey PSU. In columns marked "no interaction" age-in-months × sex indicators are controlled; in columns marked "India interaction," age-in-months × sex × India indicators are controlled (compare with the sensitivity to how age is controlled in Table A.5).

Table A.15: Controlling for sibsize in the "completed fertility" subsample reverses the negative birth order gradient in India

	(1)	(2)	(3)	(4)	(5)	(6)
region:	India	India	India	India	SSA	SSA
sample:	main height		completed fertility		completed fertility	
2nd born	-0.120***	0.0163	-0.124***	-0.0114	0.0502	0.0145
	(0.0193)	(0.0251)	(0.0253)	(0.0300)	(0.0335)	(0.0477)
3rd born	-0.318***	0.0691	-0.357***	0.00242	0.000693	-0.0118
	(0.0252)	(0.0429)	(0.0315)	(0.0494)	(0.0366)	(0.0715)
4th born	-0.386***	0.177**	-0.448***	0.112	0.0266	0.0320
	(0.0308)	(0.0629)	(0.0364)	(0.0713)	(0.0370)	(0.0914)
5th born	-0.525***	0.169†	-0.581***	0.104	-0.00876	0.0418
	(0.0398)	(0.0911)	(0.0448)	(0.104)	(0.0385)	(0.113)
sibsize indicators		✓		✓		✓
F sibsize		15.5		11.8		61.2
p sibsize		$p < 0.001$		$p < 0.001$		$p < 0.001$
age-in-months × sex	✓	✓	✓	✓	✓	✓
n (≤5th born)	38,674	38,674	25,428	25,428	23,804	23,804

Note: In all columns the dependent variable is the child's height-for-age z-score. We follow JP's definition of completed fertility. Only children of birth order 5 or less are included. Columns 1 and 2 are the Indian part of the main height sample. Standard errors are clustered by survey PSU.

Table A.16: The completed fertility subsample differs from the main height sample, and selects for different mother characteristics in India and SSA

	(1)	(2)	(3)
dependent variable:	age in months	sibsize	mother's age at birth
Panel A: India			
completed fertility subsample	7.863***	1.342***	2.847***
	(0.161)	(0.0235)	(0.0646)
constant	24.54***	2.001***	22.85***
	(0.137)	(0.0200)	(0.0551)
n (India, main height sample)	41,862	41,862	41,862
Panel B: sub-Saharan Africa			
completed fertility subsample	2.626***	1.749***	5.131***
	(0.0865)	(0.0219)	(0.0565)
constant	27.08***	3.491***	25.09***
	(0.0504)	(0.0122)	(0.0302)
n (SSA, main height sample)	123,816	123,816	123,816

Note: We follow JP's definition of completed fertility. Standard errors are clustered by survey PSU.

Table A.17: The India × birth order interaction is sensitive to specification choices in JP's "completed fertility" robustness check, specifically to exclusion of multiple births (twins, triplets)

	(JP)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
sample:	[tab 2, col 4]	comp.	comp.	comp.	comp.	comp.	comp.	main
multiple births:	included	included	excluded	excluded	excluded	excluded	excluded	excluded
Panel A: All available births, birth order coded as by JP								
2nd born × India	-0.110†	-0.078	-0.050	-0.022	-0.021	-0.025	-0.026	-0.026
	(0.063)	(0.059)	(0.056)	(0.056)	(0.054)	(0.055)	(0.053)	(0.031)
3rd+ born × India	-0.193*	-0.115	-0.068	-0.006	0.041	0.034	0.030	0.069
	(0.092)	(0.085)	(0.083)	(0.082)	(0.081)	(0.081)	(0.075)	(0.049)
n	66,566	67,459	65,506	65,506	67,194	67,194	67,194	165,678
Panel B: Last and next-to-last births (at time of survey) only, last-born indicator								
last-born × India		0.007	0.055	0.071*	0.063†	0.062†	0.050†	0.072**
		(0.035)	(0.036)	(0.034)	(0.032)	(0.033)	(0.028)	(0.022)
n		64,867	63,144	63,144	64,862	64,862	64,862	160,312
birth order & India	yes	yes	yes	yes	yes	yes	yes	yes
sibsize × India	yes	yes	yes	yes	yes	yes	yes	no
mother age × India	yes	yes	yes	no	no	no	no	no
PSU FEs	yes	yes	yes	yes	no	no	no	no
literacy × India	yes	yes	yes	yes	yes	no	no	no
child age × India	yes	yes	yes	yes	yes	yes	no	no
child age	no	no	no	no	no	no	yes	yes
sibsize × India × comp.	no	no	no	no	no	no	no	yes

Note: In all columns the dependent variable is the child's height-for-age z-score. "comp." = completed fertility sub-sample; "main" = main height sample. "Completed fertility" is an indicator for being in the completed fertility subsample. We follow JP's classification of mothers into the completed fertility subsample if they report being sterilized or infecund, or report wanting no more children; section C discusses these results. Sample sizes vary because JP's controls are not observed for all mothers. Standard errors are clustered by survey PSU. Although in other tables we prefer to control for child age × sex, here we control for age only, to match JP's specification.

Table A.18: Our main finding — that JP's negative interaction between India and being later-born is reversed either by controlling for sibsize or by focusing on the last two births of a sibsize — is robust to including multiple births (twins, triplets) in the sample

	(JP: table 2, col 2)	(1)	(2)	(3)	(4)
birth orders:	all	all	all	last two	last two
India	0.092	0.087	0.136	-0.185	0.0760
	(0.018)	(0.0212)	(0.0259)	(0.0223)	(0.0333)
2nd born × India	-0.144	-0.148	-0.0219		
	(0.025)	(0.0245)	(0.0306)		
3rd+ born × India	-0.377	-0.374	0.0609		
	(0.024)	(0.0251)	(0.0476)		
2nd born	0.023	0.0258	0.00370		
	(0.015)	(0.0153)	(0.0210)		
3rd+ born	-0.066	-0.0627	-0.0421		
	(0.013)	(0.0133)	(0.0310)		
India × last-born				0.134	0.0591
				(0.0210)	(0.0213)
last-born				0.0366	0.0421
				(0.0130)	(0.0132)
age-in-months FEs	✓	✓	✓	✓	✓
sibsize × India			✓		✓
F (sibsize × India)			167		246
p (sibsize × India)			$p < 0.001$		$p < 0.001$
n (includes multiples)	168,108	170,149	170,149	164,255	164,255

Note: In all columns the dependent variable is the child's height-for-age z-score. Standard errors are clustered by survey PSU. As we explain in the text, every table and figure we show, other than Table A.17, follows Black et al. (2005) in excluding multiple births. JP includes these observations by assigning them all the birth order of the first-born of the multiple set. Here, we code multiples as JP does and show that in this sample, as is true when multiple births are excluded, JP's negative interaction between India and being later-born is reversed either by controlling for sibsize or by focusing on the last two births of a sibsize.