Online Appendix to Intergenerational Transmission of maternal Health: Evidence from Cebu, the Philippines

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Appendix A Choosing an Optimal Instrument via Singular Value Analysis

The ordinary least squares (OSL) estimator minimizes $||\mathbf{X}\beta - \mathbf{y}||^2$, where $\mathbf{X}$ is an $m \times n$ matrix, β is an $m \times 1$ matrix, and $\mathbf{y}$ is an $m \times 1$ matrix. Yet singular value analysis (SVA) solves the same problem, by minimizing an equivalent distance problem in a rotated space.

First, using singular value decomposition (SVD), we may decompose $\mathbf{X}$ as follows

$$\mathbf{X} = \mathbf{USV^T}$$

where $\mathbf{U}$ is an orthogonal $m \times n$ matrix, $\mathbf{S}$ is a diagonal $n \times n$ matrix with successive, positive and non-decreasing entries of singular values, and $\mathbf{V^T}$ is an orthogonal $n \times n$ matrix.

Because $\mathbf{U}$ is orthogonal, $\mathbf{U}^T$ is also orthogonal, and both are therefore distance preserving under multiplication. Thus,

$$\begin{aligned}
||\mathbf{X}\beta - \mathbf{y}||^2 &= ||\mathbf{U}^T(\mathbf{X}\beta - \mathbf{y})||^2 \\
&= ||\mathbf{U}^T(\mathbf{USV^T}\beta - \mathbf{y})||^2 \\
&= ||\mathbf{SV^T}\beta - \mathbf{U}^T\mathbf{y})||^2 \\
&= ||\mathbf{S}\gamma - \mathbf{g}||^2
\end{aligned}$$

where the third line follows from the fact that $\mathbf{U}$ is an orthogonal matrix, and we define $\gamma = \mathbf{V}^{\mathbf{T}}\beta$ and $\mathbf{g} = \mathbf{U}^{T}\mathbf{y}$, both $n \times 1$ matrices.

To minimize $||\mathbf{X}\beta - \mathbf{y}||^2$, we can therefore choose a $\widehat{\gamma}$ to minimize $||\mathbf{S}\gamma - \mathbf{g}||^2$. The original parameter vector $\widehat{\beta}$ is calculated as $\mathbf{V}\widehat{\gamma}$.

Predicted outcome $\widehat{\mathbf{y}}$ may be equivalently calculated as either $\mathbf{X}\widehat{\beta}$ or $\mathbf{US}\widehat{\gamma}$, since $\mathbf{X}\beta \simeq \mathbf{y}$ and $\mathbf{S}\widehat{\gamma} \simeq \mathbf{g} = \mathbf{U}^{T}\mathbf{y}$. The residual $\widehat{\mathbf{r}}$ may be equivalently calculated as either $\mathbf{y} - \mathbf{X}\widehat{\beta}$ or $\mathbf{U}(\mathbf{g} - \mathbf{S}\widehat{\gamma})$ since $\mathbf{y} - \mathbf{X}\beta = \mathbf{Ug} - \mathbf{USV}^{\mathbf{T}}\beta = \mathbf{U}(\mathbf{g} - \mathbf{S}\gamma)$.

However, because $\mathbf{S}$ holds successively non-increasing diagonal values, the elements of $\widehat{\gamma}$ become increasingly insignificant to $\widehat{\beta} = \mathbf{V}\widehat{\gamma}$. The candidate solution $\gamma^{(k)}$ may therefore be considered, where each element of $\gamma^{(k)}$ is identical to that of the full solution $\widehat{\gamma}$ up until the k'th element, and all subsequent elements are zero, as below.

$$\gamma^{(k)} = \begin{bmatrix} \widehat{\gamma}_1 \\ \vdots \\ \widehat{\gamma}_k \\ 0 \\ \vdots \\ 0 \end{bmatrix}$$

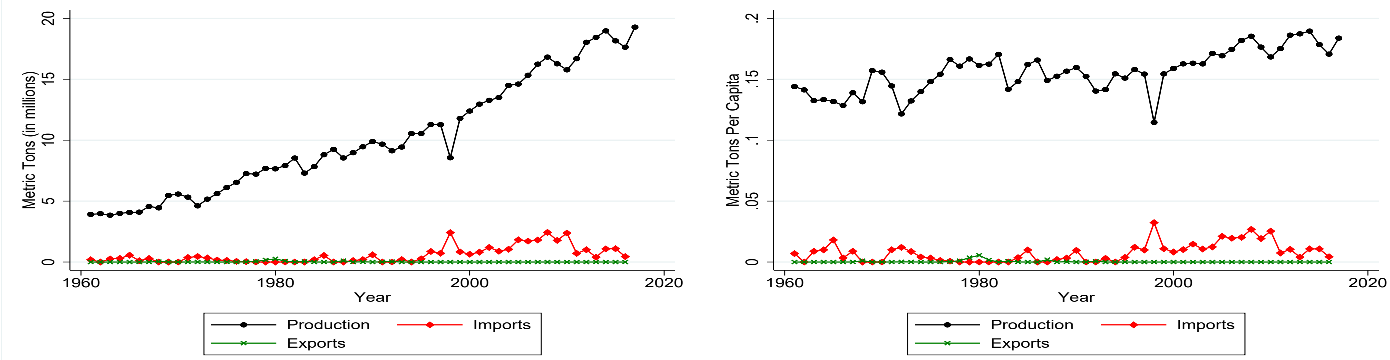
In many cases the candidate solution $\gamma^{(k)}$, for some particular $k < n$, minimizes mean squared forecasting error (MSFE) better than the full solution γ. This is because the rows of matrix **V** hold "averages" for the columns of matrix **X**, but with each row explaining less and less of the variation in **X**. One might imagine that, past some particular column k, the rows of matrix **V** hold only sample-specific variation in **X**, rather than variation that can be predicted out of sample. In other words, a solution vector $\widehat{\beta}$ that captures such variation is over-fitting the model, leading to an increase in R^2 within sample, but also an increase in MSFE out of sample. A solution vector $\widehat{\beta}$ that captures only the variation within the first k vectors of **V** will better minimize MSFE.

Often, k is chosen based on the condition number of the implied system, i.e., the instability of the solution. We instead choose k using k-fold cross-validation, with 100 folds. (This is the same procedure we use to choose the optimal penalty function in our Lasso models.) To be explicit, the sample is split into 100 groups (no replacement). Forecast error (MSE) is then calculated sequentially for each of those 100 (test) groups, after estimating the SVA parameters in the remaining 99% of the (training) data for every model size k. Forecast error is averaged by k to find the k that minimizes this error. Using 10 folds rather than 100 folds creates virtually identical results.

Appendix B Extra Results and Robustness Checks

Appendix B.1 Rice Trade and Production in the Philippines

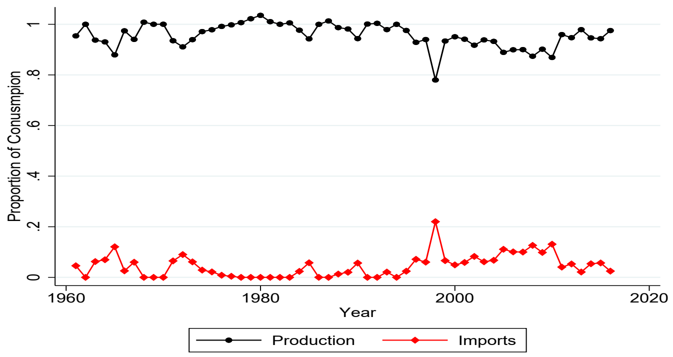
Figure B.1: Rice Production and Trade, the Philippines 1961—2017



Notes: This figure plots rice production (black circle), rice imports (red diamond), and rice exports (green x) in the Philippines, during the years 1961 to 2016. The left panel reports total rice production and trade and the right panel reports per capita production and trade. Together with Figure B.2, this figure illustrates that Filipino rice is largely self-supplied and thus Filipino rice consumption is likely sensitive to domestic production shocks.

Source: Food and Agricultural Organization (FAO): http://www.fao.org/faostat/en/#data

Figure B.2: Rice Production and Trade as Proportion of Consumption, the Philippines 1961—2017



Notes: This figure plots rice production (black circle) and rice imports (red diamond) as a percentage of rice consumption in the Philippines, during the years 1961 to 2016. Together with Figure B.1, this figure illustrates that Filipino rice is largely self-supplied and thus Filipino rice consumption is likely sensitive to domestic production shocks.

Source: Food and Agricultural Organization (FAO): http://www.fao.org/faostat/en/#data

Appendix B.2 Sample Description

Table B.1: Baseline Characteristics across Sub-Samples of Children

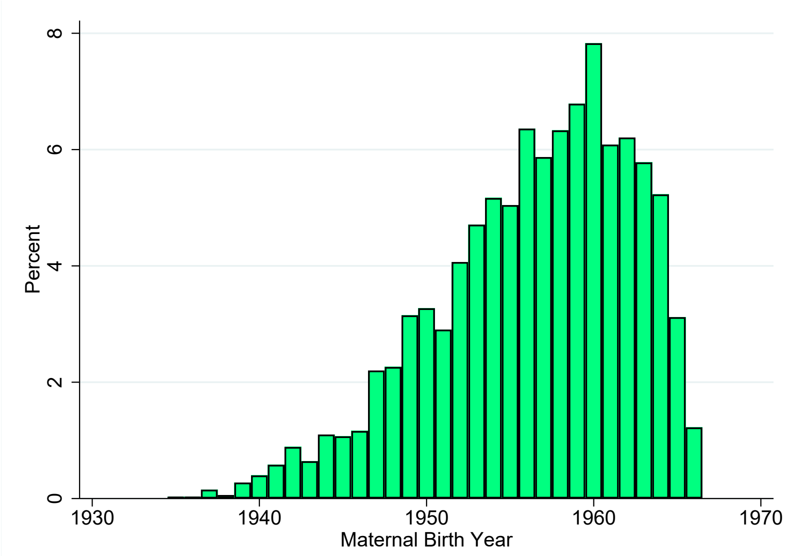
	Full Sample (1)	Attrit Before Year 8 (2)	Balanced Panel (3)	Difference Columns (2)-(1) (5)	Difference Columns (3)-(1) (5)
Mother's height (cm)	150.80	150.67	150.76	-0.13	-0.04
	(5.11)	(5.10)	(5.06)	(0.21)	(0.15)
Mother's skinfold (cm)	12.15	12.01	12.12	-0.15	-0.04
	(3.79)	(3.85)	(3.67)	(0.15)	(0.11)
Mother's MUAC	24.68	24.70	24.64	0.02	-0.04
	(2.38)	(2.48)	(2.30)	(0.10)	(0.07)
Height-for-age Z-score	-0.56	-0.66	-0.53	-0.10**	0.03
	(1.08)	(1.16)	(1.05)	(0.04)	(0.03)
Birth Weight (grams)	2,997.31	2,960.79	3,005.20	-36.52**	7.90
	(446.30)	(470.09)	(428.59)	(18.33)	(12.78)
Mother's Age	26.80	26.77	26.82	-0.02	0.02
	(5.87)	(5.73)	(5.86)	(0.24)	(0.17)
Low birth Weight	0.12	0.14	0.10	0.03**	-0.01
	(0.32)	(0.35)	(0.31)	(0.01)	(0.01)
Per Capital Income	2,775.26	2,776.32	2,738.86	1.06	-36.40
	(4,026.92)	(4,656.18)	(3,876.11)	(169.07)	(115.41)
Household Size	5.67	5.44	5.76	-0.23**	0.09
	(2.81)	(2.81)	(2.81)	(0.11)	(0.08)
Mother grade attainment	7.58	7.74	7.43	0.16	-0.15
	(3.72)	(3.73)	(3.69)	(0.15)	(0.11)
Child died in first 2 years	0.04	0.16	0.00	0.12***	-0.04***
	(0.20)	(0.37)	(0.00)	(0.01)	(0.00)
N	2,990	760	1,955		

Notes: This table average baseline characteristics for the full baseline working sample (Column 1), the sample of children who attrited from the sanple before the age 8 survey (Coumn 2), and for the balanced panel of children who were observed in every survey wave (Column 3). Columns 5 and 6 report average differences between the full working sample and the early attrition and balanced samples, respectively. Standard errors are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table B.1 reports average characteristics for the full baseline working sample, the sample of children who attrit before age 8 (i.e., attrit before age 2 or between age 2 and age 8 surveys), and the balanced panel (i.e., the sample of children who appear in all survey waves from birth through age 15) in Columns 1, 2, and 3, respectively. Columns 5 and 6 report the average difference between the sample means of the full baseline working sample and each of the two subsamples. Table B.1 reports three measures of mother's baseline health (height, skinfold thickness, and middle upper arm circumference (MUAC)). We see no average difference in mother's health across the three samples. However, children who attrited before age 8, appear to be less healthy, on average, in their early childhood. These children were shorter, on average, had lower average birthweight, were more likely to be born at a low birth weight, and were more likely to die in their first two years of life (which would, of course, explain their attrition). We also see that the early attriters were more likely to come from a slightly from a larger household, on average.

However, we also see in Table B.1, these differences are not reflected in the balanced panel. For the most part, average differences between the full baseline working sample and the balanced panel are statistically insignificant and small in magnitude. The only statistically significant differences between the two samples is in the proportion of children who died in the first two years of life. We repeated all anlaysis using the sample that excludes early attritors as well as with the balanced panel. These results are available upon request and are nearly identical to our main results.

Figure B.3: Distribution of Sample Mothers' Year of Birth

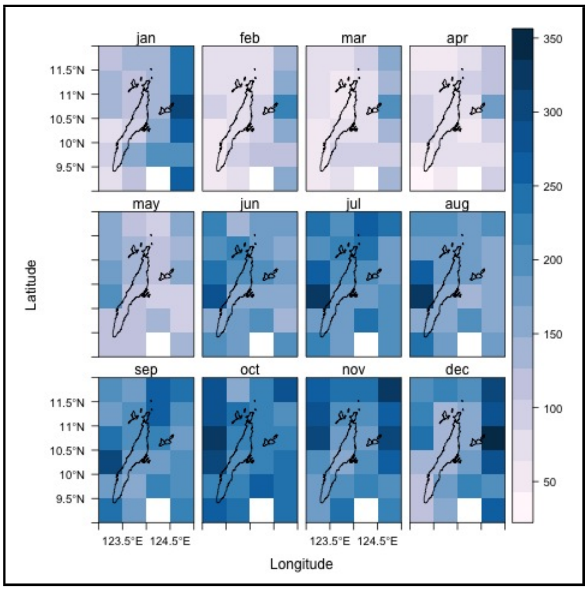


Notes: This figure shows the distribution of maternal birth year for our sample. Most of our sample mothers were born in the 1950s and early 1960s.

While we know sample women's year of birth (see Figure B.3), we do not know their exact location of birth, unless it is their current locality. We can say with certainty that approximately 34% of our sample women were born in the Cebu Metropolitan area—these are the women who report that they were born in their baseline survey location.While we do not know the exact barangay of birth for other sample women, we do know that at least 70% of our sample women were born on and spent their early childhood somewhere on Cebu island (if not the Cebu Metropolitan Area). We think the figure is actually higher than 70%, but cannot confirm this. In any case, given that the majority of women in our sample grew up on Cebu island, but not necessarily in Cebu Metropolitan area, we think that weather shocks over the entire island are likely to best capture early life maternal health.

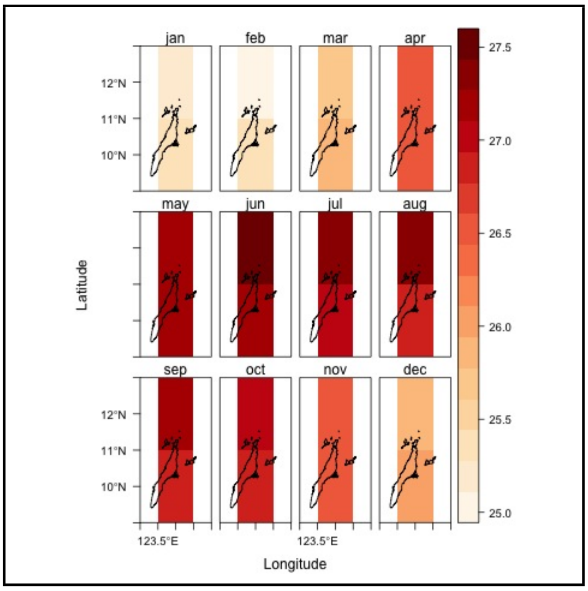
Second, we are identifying largely on shocks to the monsoon weather conditions and pre-harvest conditions, and we think that shocks along the entirety of Cebu island would have influenced food availability and nutritional status in Cebu City (and surrounding areas). This is a second reason to use weather shocks over the entire island. For both of those reasons, we did a weighted extraction of all gridded weather layers for the whole island. Figures B.4, B.5, and B.7 describe monthly weather conditions on the island of Cebu.

Figure B.4: Monthly Average Rainfall



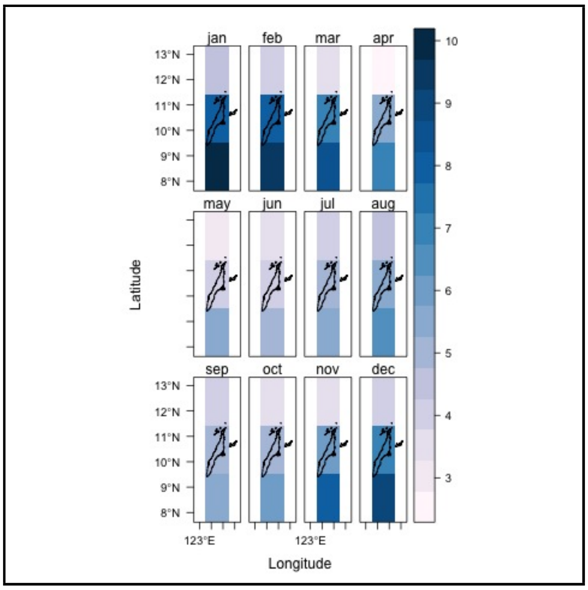
Notes: This figure illustrates average rainfall (mm/day) on the island of Cebu across months.

Figure B.5: Monthly Average Temperature



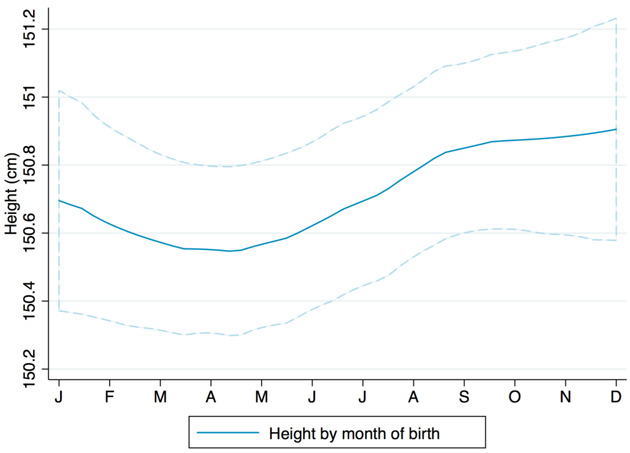
Notes: This figure illustrates average temperature (Celsius) on the island of Cebu across months.

Figure B.6: Monthly Average Windspeed



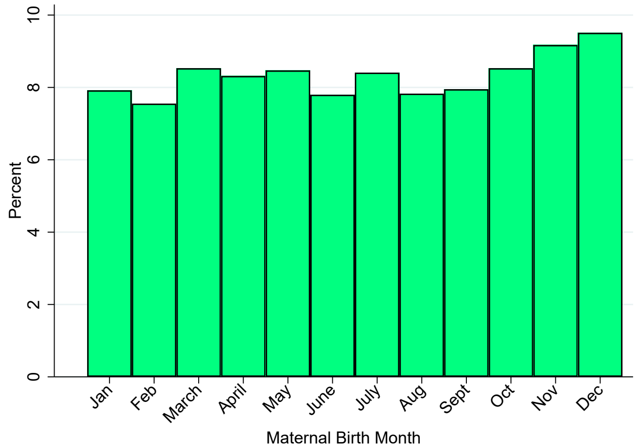
Notes: This figure illustrates average windspeed (m/s) on the island of Cebu across months.

Figure B.7: Mother's Height by Month of Birth



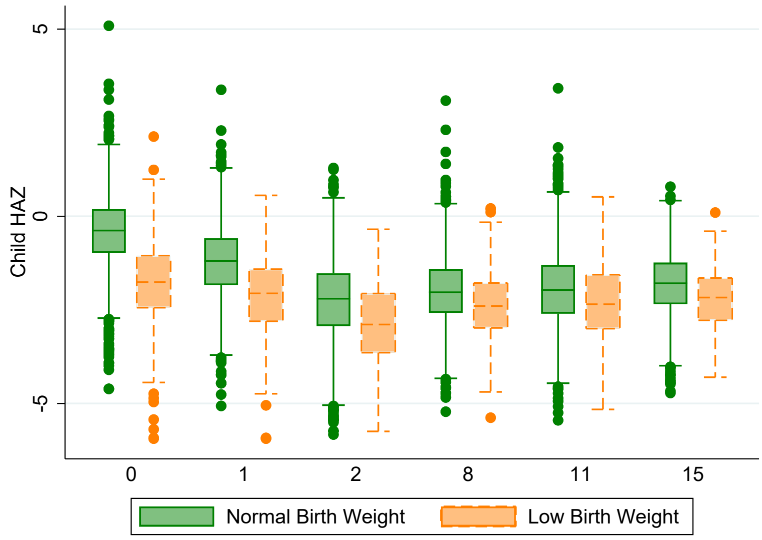
Notes: This figure plots sample mothers' average height by their month of birth with 95% confidence intervals. Here we see that mother's height exhibits distinct seasonality depending on her month of birth.

Figure B.8: Maternal Month of Birth



Notes: This figure illustrates the distribution of maternal birth months. Mothers' month of birth is fairly evenly distributed across months—meaning that mothers born in a particular month or season are not overweighted in our estimates.

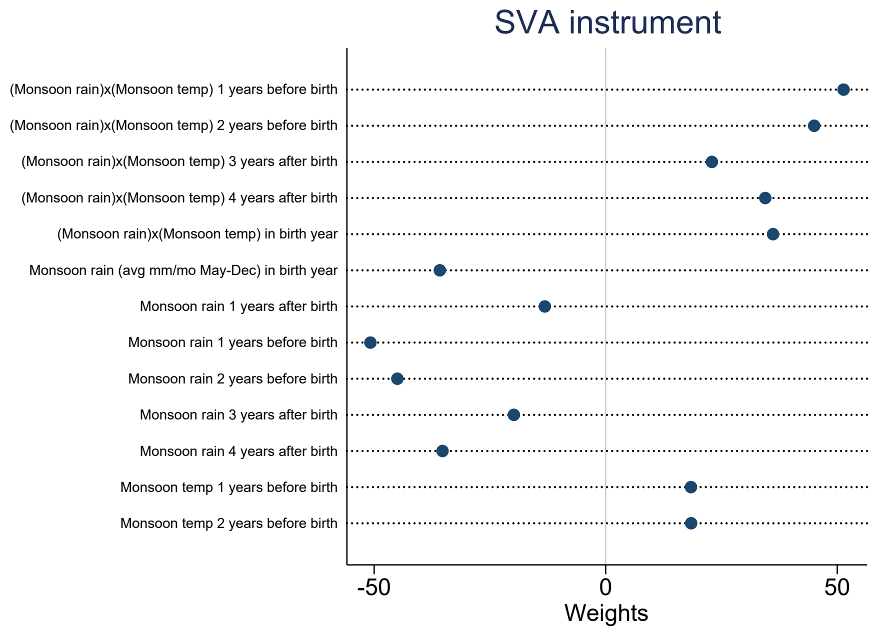
Figure B.9: Box Plot of Median HAZ across Ages for Children Born and Normal and Low Birthweight



Notes: This figure is a boxplot of our sample children's HAZ at each observed age, separated by whether they were born at a normal or low birthweight. In this figure we see that low birthweight children experience some early catch-up growth while those born at a normal birth weight experience early growth faltering. Both movements cause disparities in median HAZ between the two groups to diminish as the children age.

Appendix B.3 First-stage Variation

Figure B.10: Variables Providing Main Identifying Variation for SVA instrument



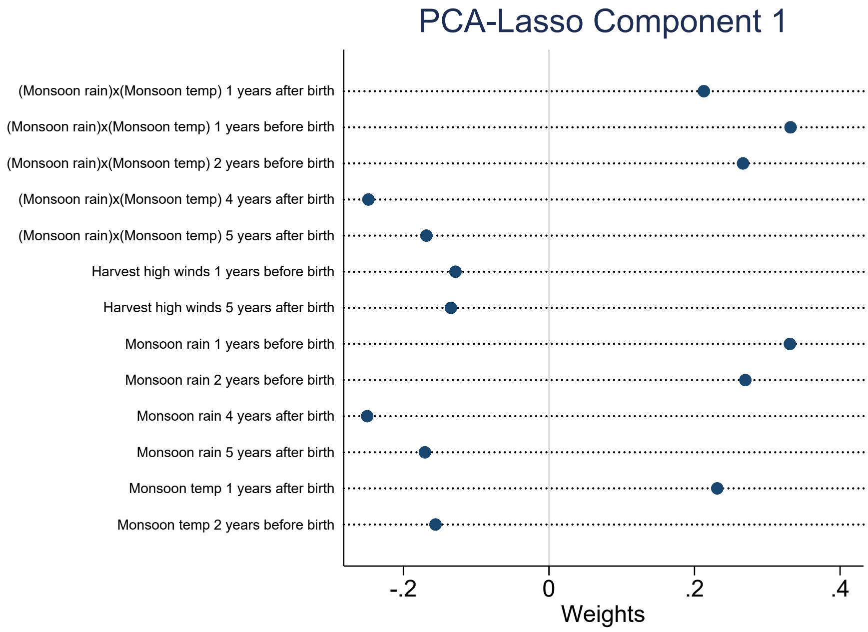
Notes: This figure describes the primary sources of variation in generating our SVA-optimal instrument. For the original climate instruments that provide the bulk of the variation, this figure provides the average contribution of these instruments to the SVA-optimal instrument (given by the instruments coefficient from Equation 3 multplied by the mean of the instrument). See Section IV.B for details.

Table B.2: Identifying Variation Provided in First-stage from Instruments Chosen by Lasso

Variables Chosen	Weights
Max windspeed 12 mo prior to birth	0.27
Max windspeed 11 mo prior to birth	0.24
Max windspeed 10 mo prior to birth	-0.48
Max windspeed 9 mo prior to birth	-0.39
Max windspeed 8 mo prior to birth	-0.27
Max windspeed 5 mo prior to birth	-0.14
Max windspeed 4 mo prior to birth	-0.39
Max windspeed 3 mo prior to birth	0.19
Max windspeed 1 mo prior to birth	-0.43
Max windspeed 6 mo after birth	0.42
Max windspeed 8 mo after birth	-0.25
Max windspeed 10 mo after birth	0.31
Monsoon rain 2 years before birth	0.17
Monsoon rain 3 years after birth	1.04
Monsoon rain 5 years after birth	0.53
Monsoon temp 1 years before birth	**29.75**
Monsoon temp 3 years after birth	**48.72**
Monsoon temp 4 years after birth	**37.86**
Harvest high winds 2 years before birth	**-1.45**
Harvest high winds the year of birth	**-0.73**
Harvest high winds 2 years after birth	**-0.83**
Harvest high winds 3 years after birth	-0.65
Born in month 3	-0.05
Born in month 11	0.07

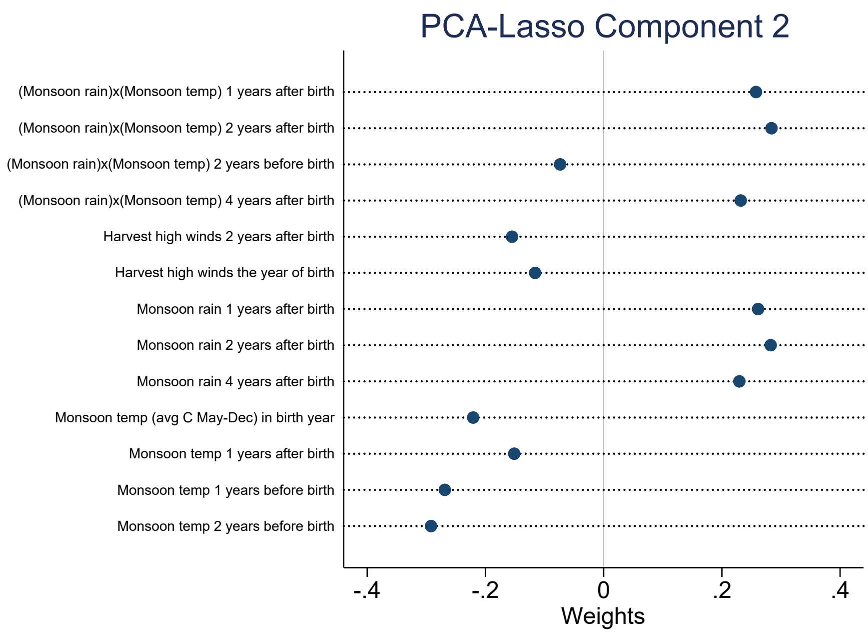
Notes: This figure reports the average contribution of the Lasso-chosen instruments to a first-stage predicting maternal height. Instruments providing the main identifying information are in bold. See Section IV.B for details.

Figure B.11: Variables Providing Main Identifying Variation for 1^{st} PCA-Lasso Instrument



Notes: This figure describes the primary sources variation in the first Lasso-chosen principle component when using PCA-Lasso in the first-stage. For the original climate instruments that provide the bulk of the variation, this figure provides the weight of these instruments' contribution to this component. See Section IV.B for details.

Figure B.12: Variables Providing Main Identifying Variation for 2^{nd} PCA-Lasso Instrument



Notes: This figure describes the primary sources variation in the second Lasso-chosen principle component when using PCA-Lasso in the first-stage. For the original climate instruments that provide the bulk of the variation, this figure provides the weight of these instruments' contribution to this component. See Section IV.B for details.

Table B.3: First Stage Results Predicting Maternal Height using SVA-Optimal Instrument in the First-Stage across Ages

	(1) Birth	(2) Age 1	(3) Age 2
Optimal SVA for Mother's Height (k=45)	0.872***	0.910***	0.821***
	(0.116)	(0.115)	(0.124)
Observations	2988	2996	2604
First-stage R^2	0.0529	0.0443	0.0481
IV Effective Fstat	58.43	64.20	45.40
	Age 8	Age 11	Age 15
Optimal SVA for Mother's Height (k=45)	0.930***	0.957***	0.922***
	(0.162)	(0.169)	(0.194)
Observations	2210	2133	2045
First-stage R^2	0.114	0.125	0.135
IV Effective Fstat	34.02	32.99	23.36

Notes: This table reports first-stage results for Equation 1 when using our SVA-optimal instrument to predict maternal height (cm) in the first-stage for each observed age. The first-stage for each age differs slightly by sample due to attrition and interuption but are otherwise identical. Controls include child gender, mother's age, mother age cohorts, birth month fixed effects, and baseline and current barangay fixed effects (which are equivalent in first two years). For birth outcomes only an indicator for whether gestational age is in question is also included. First-stage results for Equations 4, 5, and 6 are largely similar and additionally include the controls specified for those equations—see Section V.A for details. Olea and Pfluefer effective F-statistics are reported. Clustered standard errors are in parentheses.

Table B.4: First Stage Results Predicting Maternal Height using Lasso-Chosen Instruments across Ages

	(1) Birth	(2) Age 1	(3) Age 2	(4) Age 8	(5) Age 11	(6) Age 15
Max windspeed 12 mo prior to birth	0.00167	0.00214	0.00154	0.00281*	0.00262	0.00248
	(0.00164)	(0.00161)	(0.00163)	(0.00164)	(0.00168)	(0.00161)
Max windspeed 11 mo prior to birth	0.00120	0.00127	0.00203	0.00213	0.000262	0.000699
	(0.00177)	(0.00176)	(0.00199)	(0.00225)	(0.00223)	(0.00224)
Max windspeed 10 mo prior to birth	-0.00282	-0.00298*	-0.00336*	-0.00442**	-0.00465*	-0.00441*
	(0.00174)	(0.00168)	(0.00183)	(0.00194)	(0.00254)	(0.00235)
Max windspeed 9 mo prior to birth	-0.00430**	-0.00431**	-0.00313	-0.00460*	-0.00454	-0.00363
	(0.00203)	(0.00207)	(0.00236)	(0.00243)	(0.00293)	(0.00279)
Max windspeed 8 mo prior to birth	-0.00212	-0.00216	-0.00218	-0.00357	-0.00353	-0.00192
	(0.00183)	(0.00180)	(0.00197)	(0.00222)	(0.00238)	(0.00247)
Max windspeed 5 mo prior to birth	-0.000201	-0.000403	0.000371	-0.000553	-0.000218	0.000842
	(0.00178)	(0.00178)	(0.00204)	(0.00247)	(0.00250)	(0.00244)
Max windspeed 4 mo prior to birth	-0.00264	-0.00263	-0.00331*	-0.00312	-0.00320	-0.00251
	(0.00169)	(0.00169)	(0.00184)	(0.00194)	(0.00235)	(0.00195)
Max windspeed 3 mo prior to birth	0.000809	0.000932	0.000727	-0.00111	-0.00177	-0.000325
	(0.00158)	(0.00155)	(0.00159)	(0.00188)	(0.00207)	(0.00222)
Max windspeed 1 mo prior to birth	-0.00373**	-0.00371**	-0.00385*	-0.00484**	-0.00526**	-0.00487*
	(0.00175)	(0.00178)	(0.00200)	(0.00215)	(0.00205)	(0.00248)
Max windspeed 6 mo after birth	0.00352*	0.00377**	0.00459**	0.00477*	0.00576**	0.00542**
	(0.00175)	(0.00168)	(0.00187)	(0.00277)	(0.00256)	(0.00256)
Max windspeed 8 mo after birth	-0.00194	-0.00194	-0.00200	-0.00230	-0.00301	-0.00233
	(0.00179)	(0.00181)	(0.00196)	(0.00240)	(0.00239)	(0.00249)
Max windspeed 10 mo after birth	0.00362**	0.00382**	0.00360	0.00304	0.00473*	0.00393
	(0.00174)	(0.00175)	(0.00219)	(0.00305)	(0.00278)	(0.00279)
Monsoon rain 2 years before birth	-0.00373	-0.00410	-0.00468	-0.00178	0.00308	0.00129
	(0.00329)	(0.00330)	(0.00393)	(0.00602)	(0.00555)	(0.00566)
Monsoon rain 3 years after birth	0.00747**	0.00739**	0.00532	0.00435	0.00787*	0.00856*
	(0.00307)	(0.00304)	(0.00333)	(0.00442)	(0.00458)	(0.00454)
Monsoon rain 5 years after birth	-0.000298	-0.000782	-0.000962	-0.000516	0.00659	0.00395
	(0.00382)	(0.00386)	(0.00379)	(0.00498)	(0.00516)	(0.00540)
Monsoon temp 1 years before birth	1.133	1.300*	1.051	1.157	0.826	0.761
	(0.695)	(0.681)	(0.631)	(0.884)	(0.965)	(0.986)
Monsoon temp 3 years after birth	1.098	1.148	0.855	1.018	1.326	1.252
	(0.924)	(0.914)	(0.957)	(0.929)	(0.951)	(1.082)
Monsoon temp 4 years after birth	1.889**	1.928**	1.839**	0.822	-0.272	0.466
	(0.702)	(0.707)	(0.845)	(1.002)	(1.087)	(1.060)
Harvest Max Winds 2 Years before Birth	-0.00952**	-0.00957***	-0.00898***	-0.00883**	-0.0105**	-0.00970**
	(0.00349)	(0.00331)	(0.00303)	(0.00374)	(0.00387)	(0.00428)
Harvest Max Winds Year of Birth	-0.00758	-0.00799	-0.00881	-0.00328	-0.00279	-0.00537
	(0.00497)	(0.00496)	(0.00524)	(0.00736)	(0.00774)	(0.00759)
Harvest Max Winds 2 Years after Birth	-0.00427	-0.00389	-0.00586	-0.00701	-0.00965	-0.0114
	(0.00501)	(0.00490)	(0.00531)	(0.00546)	(0.00610)	(0.00717)
Harvest Max Winds 3 Years after Birth	-0.00779	-0.00769	-0.00880	-0.00479	0.00358	-0.00113
	(0.00548)	(0.00549)	(0.00526)	(0.00714)	(0.00788)	(0.00815)
Born in month 3	-0.460	-0.521	-0.382	-0.429	-0.0271	-0.216
	(0.324)	(0.331)	(0.355)	(0.432)	(0.477)	(0.406)
Born in month 11	0.738**	0.740**	1.111***	1.082**	1.158**	1.005**
	(0.286)	(0.287)	(0.333)	(0.455)	(0.436)	(0.453)
Observations	2988	2996	2604	2210	2133	2045
First-stage R^2	0.0534	0.0448	0.0518	0.117	0.130	0.138
IV Effective Fstat	2.224	2.428	2.145	1.799	1.920	1.564

Notes: This table reports first-stage results for Equation 1 when using the Lasso-chosen instruments to predict maternal height (cm) in the first-stage for each observed age. The first-stage for each age differs slightly by sample due to attrition and interuption but are otherwise identical. Controls include child gender, mother's age, mother age cohorts, birth month fixed effects, and baseline and current barangay fixed effects (which are equivalent in first two years). For birth outcomes only an indicator for whether gestational age is in question is also included. First-stage results for Equations 4, 5, and 6 are largely similar and additionally include the controls specified for those equations—see Section V.A for details. Olea and Pfluefer effective F-statistics are reported. Clustered standard errors are in parentheses.

Table B.5: First Stage Results Predicting Maternal Height using Lasso-Chosen Principal Components across Ages

	(1) Birth	(2) Age 1	(3) Age 2	(4) Age 8	(5) Age 11	(6) Age 15
Score for component 2	0.0280	0.0353	0.0230	-0.00541	-0.0241	-0.0126
	(0.0425)	(0.0439)	(0.0463)	(0.0641)	(0.0600)	(0.0620)
Score for component 3	0.0790	0.0880	0.113	0.0192	0.0623	0.124
	(0.0646)	(0.0665)	(0.0773)	(0.0769)	(0.0841)	(0.0830)
Score for component 4	0.0492	0.0558	0.0552	0.0598	-0.0207	-0.0537
	(0.0499)	(0.0473)	(0.0474)	(0.0654)	(0.0631)	(0.0705)
Score for component 5	0.0502	0.0573	0.0232	-0.0390	0.0177	0.00849
	(0.0411)	(0.0428)	(0.0488)	(0.0678)	(0.0668)	(0.0782)
Score for component 8	-0.0434	-0.0478	-0.0533	-0.0948	-0.0537	-0.0422
	(0.0478)	(0.0503)	(0.0501)	(0.0693)	(0.0731)	(0.0718)
Score for component 9	0.110*	0.115*	0.100	0.0939	0.180**	0.145*
	(0.0588)	(0.0604)	(0.0627)	(0.0721)	(0.0758)	(0.0744)
Score for component 11	0.119*	0.113	0.0917	0.0819	0.136	0.110
	(0.0699)	(0.0705)	(0.0872)	(0.0876)	(0.0874)	(0.0927)
Score for component 14	-0.203**	-0.206**	-0.206*	-0.142	-0.212	-0.189
	(0.0869)	(0.0880)	(0.103)	(0.131)	(0.132)	(0.122)
Score for component 19	0.0144	0.0349	0.0464	0.0690	0.0854	0.0217
	(0.102)	(0.101)	(0.115)	(0.148)	(0.146)	(0.141)
Score for component 20	0.0969	0.110	0.0595	0.107	0.129	0.109
	(0.0848)	(0.0835)	(0.0892)	(0.0992)	(0.103)	(0.108)
Score for component 21	0.170*	0.164*	0.172*	0.211*	0.273**	0.228*
	(0.0895)	(0.0875)	(0.100)	(0.120)	(0.127)	(0.134)
Score for component 24	0.181**	0.203**	0.166*	0.320***	0.367***	0.341***
	(0.0823)	(0.0828)	(0.0941)	(0.0866)	(0.0857)	(0.0736)
Score for component 25	-0.137	-0.139	-0.0810	-0.179	-0.0910	-0.114
	(0.103)	(0.104)	(0.110)	(0.131)	(0.126)	(0.127)
Score for component 27	0.0721	0.0837	0.0637	0.137	0.232*	0.236*
	(0.0967)	(0.0964)	(0.115)	(0.130)	(0.134)	(0.135)
Score for component 29	0.211**	0.219**	0.310***	0.307**	0.227*	0.214
	(0.0942)	(0.0973)	(0.102)	(0.140)	(0.134)	(0.143)
Score for component 32	0.224**	0.228**	0.212*	0.298**	0.340**	0.280**
	(0.0980)	(0.0992)	(0.107)	(0.116)	(0.133)	(0.123)
Score for component 34	-0.155	-0.161	-0.114	-0.119	-0.127	-0.0944
	(0.120)	(0.120)	(0.137)	(0.158)	(0.150)	(0.145)
Score for component 35	-0.250*	-0.274*	-0.256*	-0.269*	-0.299**	-0.282**
	(0.143)	(0.141)	(0.145)	(0.143)	(0.140)	(0.133)
Score for component 38	-0.122	-0.111	-0.0988	-0.102	-0.0558	-0.0528
	(0.110)	(0.111)	(0.127)	(0.159)	(0.149)	(0.151)
Score for component 42	0.249	0.257*	0.319*	0.300	0.331	0.361
	(0.151)	(0.148)	(0.159)	(0.194)	(0.197)	(0.222)
Score for component 47	-0.460***	-0.474***	-0.517***	-0.378**	-0.290	-0.422**
	(0.106)	(0.102)	(0.115)	(0.185)	(0.195)	(0.195)
Score for component 49	-0.343**	-0.328**	-0.329*	-0.282	-0.258	-0.407**
	(0.153)	(0.157)	(0.162)	(0.175)	(0.209)	(0.194)
Score for component 50	0.354*	0.333*	0.351	0.294	0.102	0.164
	(0.189)	(0.185)	(0.215)	(0.216)	(0.242)	(0.243)
Score for component 51	0.365**	0.368**	0.280	0.427	0.385	0.437*
	(0.163)	(0.169)	(0.173)	(0.266)	(0.243)	(0.225)
Score for component 59	1.193	1.223	1.155	1.418	1.422*	1.359
	(0.875)	(0.878)	(0.892)	(0.961)	(0.826)	(0.919)
Observations	2990	2980	2606	2210	2133	2045
First-stage R^2	0.0579	0.0493	0.0557	0.124	0.135	0.145
IV Effective Fstat	2.633	2.812	2.364	2.110	2.198	2.066

Notes: This table reports first-stage results for Equation 1 when using the PCA components chosen by Lasso as instruments for maternal height (cm) in the first-stage for each observed age. The first-stage for each age differs slightly by sample due to attrition and interuption but are otherwise identical. Controls include child gender, mother's age, mother age cohorts, birth month fixed effects, and baseline and current barangay fixed effects (which are equivalent in first two years). For birth outcomes only an indicator for whether gestational age is in question is also included. First-stage results for Equations 4, 5, and 6 are largely similar and additionally include the controls specified for those equations—see Section V.A for details. Olea and Pfluefer effective F-statistics are reported. Clustered standard errors are in parentheses.

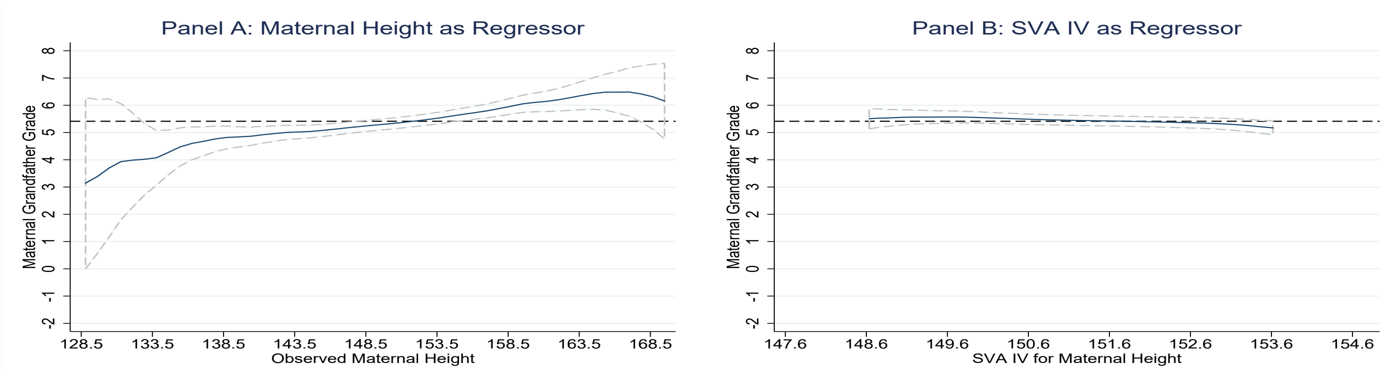
Table B.6: Mother-to-Child Health Transmission Estimates using OLS, Traditional 2SLS, SVA 2SLS, SVA Reduced Form

	Birth Height Zscore				**Birth Weight**			
	(1) OLS	(2) 2SLS (All IVs)	(3) 2SLS (SVA IV)	(4) Reduced Form on SVA IV	(5) OLS	(6) 2SLS (All IVs)	(7) 2SLS (SVA IV)	(8) Reduced Form on SVA IV
Mother's height (cm)	0.0336***	-0.00222	0.0206		12.69***	24.05***	30.38**	
	(0.00369)	(0.0244)	(0.0287)		(1.339)	(8.941)	(12.55)	
Optimal SVA for Mother's Height (k=45)				0.0180				26.61**
				(0.0257)				(10.78)
Observations	2988	2988	2988	2988	2990	2990	2990	2990
R^2	0.169			0.145	0.216			0.198
IV Effective Fstat		1.168	58.43			1.173	58.49	
	Age 1 Height Zscore				**Age 1 Weight Zscore**			
Mother's height (cm)	0.0582***	0.0684***	0.0931***		0.0129***	0.0610***	0.0764***	
	(0.00356)	(0.0155)	(0.0202)		(0.00285)	(0.0191)	(0.0227)	
Optimal SVA for Mother's Height (k=45)				0.0847***				0.0690***
				(0.0193)				(0.0190)
Observations	2996	2996	2996	2996	2980	2980	2980	2980
R^2	0.152			0.0705	0.0393			0.0368
IV Effective Fstat		1.235	64.20			1.222	59.12	
	Age 2 Height Zscore				**Age 2 Weight Zscore**			
Mother's height (cm)	0.0702***	0.0758***	0.134***		0.0244***	0.0495***	0.0971***	
	(0.00371)	(0.0186)	(0.0343)		(0.00329)	(0.0183)	(0.0302)	
Optimal SVA for Mother's Height (k=45)				0.110***				0.0801***
				(0.0252)				(0.0220)
Observations	2604	2604	2604	2604	2606	2606	2606	2606
R^2	0.170			0.0734	0.0624			0.0473
IV Effective Fstat		1.071	45.40			1.088	45.79	
	Age 8 Height Zscore				**Age 8 Weight Zscore**			
Mother's height (cm)	0.0680***	0.0737***	0.128***		0.00636	0.0394**	0.0768**	
	(0.00419)	(0.0180)	(0.0304)		(0.00444)	(0.0161)	(0.0311)	
Optimal SVA for Mother's Height (k=45)				0.119***				0.0714**
				(0.0225)				(0.0279)
Observations	2210	2210	2210	2210	2210	2210	2210	2210
R^2	0.229	0.228	0.134	0.116	0.107	0.0752	.	0.109
IV Effective Fstat		1.028	34.02			1.028	34.02	
	Age 11 Height Zscore				**Age 11 Weight Zscore**			
Mother's height (cm)	0.0667***	0.0718***	0.147***		0.0117***	0.0224	0.0487	
	(0.00525)	(0.0200)	(0.0290)		(0.00376)	(0.0225)	(0.0377)	
Optimal SVA for Mother's Height (k=45)				0.141***				0.0466
				(0.0240)				(0.0387)
Observations	2133	2133	2133	2133	2133	2133	2133	2133
R^2	0.194	0.193	0.0536	0.106	0.119	0.117	0.0928	0.117
IV Effective Fstat		1.123	32.99			1.123	32.99	
	Age 15 Height Zscore				**Age 15 Weight Zscore**			
Mother's height (cm)	0.0713***	0.0675***	0.109***		0.00679	0.0121	0.0618*	
	(0.00431)	(0.0115)	(0.0239)		(0.00413)	(0.0258)	(0.0358)	
Optimal SVA for Mother's Height (k=45)				0.101***				0.0569*
				(0.0281)				(0.0331)
Observations	2045	2045	2045	2045	2045	2045	2045	2045
R^2	0.279	0.278	0.231	0.119	0.143	0.142	0.0800	0.143
IV Effective Fstat		1.089	23.36			1.089	23.36	

Notes: This table compares estimates of the effect of maternal height (cm) on child health using OLS (Columns 1 and 5), traditional 2SLS with all 69 original climate IVs (Columns 2 and 6), 2SLS with our SVA-optimal IV which is identical to results reported in Table 4 (Columns 3 and 7), and reduced form estimates of child health regressed directly on the SVA-optimal IV (Columns 4 and 8). All pretreatment controls are included. Olea and Pfluefer effective F-statistics are reported. Clustered standard errors are in parenthesis.
*** p<0.01, ** p<0.05, * p<0.1.

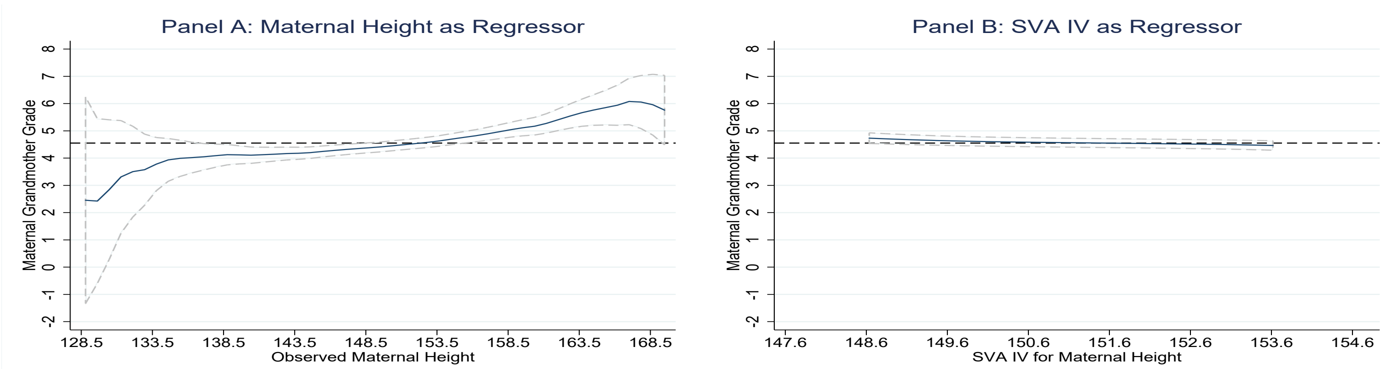
Appendix B.4 Association between Maternal Grandparent Characteristics and Maternal Height and the SVA-optimal IV

Figure B.13: Association between Maternal Grandfather Grade Attainment and Maternal Height and SVA IV



Notes: This figure plots the association between maternal grandfather grade attainment and maternal height (Panel A) and the SVA-optimal IV (Panel B). Grandfather grade attainment is significantly positively associated with endogenous maternal height but is not significantly associated with the SVA-optimal IV. The reference line indicates the sample mean of maternal grandfather grade attainment.

Figure B.14: Association between Maternal Grandmother Grade Attainment and Maternal Height and SVA IV



Notes: This figure plots the association between maternal grandmother grade attainment and maternal height (Panel A) and the SVA-optimal IV (Panel B). Grandmother grade attainment is significantly positively associated with endogenous maternal height but is not significantly associated with the SVA-optimal IV. The reference line indicates the sample mean of maternal grandmother grade attainment.

Table B.7: Effect of Maternal Maternal Height and SVA IV on Grandparent Grade Attainment

	(1) Maternal Height	(2) SVA IV
Maternal grandmother education	0.129***	-0.00454
	(0.0440)	(0.00627)
Maternal grandfather education	0.110***	0.000124
	(0.0402)	(0.00573)
Observations	1751	1751
R^2	0.0666	0.259
Fstat p-value	7.42e-09	0.685

Notes: This table reports the association between maternal grandparent grade attainment and maternal height (Column 1) and the SVA-optimal IV (Column 2). Grandparent grade attainment significantly positively predicts maternal height but does not significantly predict the SVA-optimal IV. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table B.8: Effect of Grandparent Occupation on Maternal Height and SVA IV

	Maternal Grandfather		Maternal Grandmother	
	(1) Maternal Height	(2) SVA IV	(3) Maternal Height	(4) SVA IV
Administrative	0.329	-0.0200	-2.838	-0.00158
	(1.095)	(0.156)	(1.469)	(0.209)
Clerical	0.608	-0.0263	-2.160	-0.120
	(1.122)	(0.160)	(1.773)	(0.252)
Retail/Vendor	-0.370	-0.143	-1.878*	0.0632
	(0.936)	(0.133)	(0.747)	(0.106)
Agriculture	-0.968	-0.0569	-2.227**	0.127
	(0.851)	(0.121)	(0.763)	(0.108)
Miner	0.529	0.0125		
	(1.148)	(0.163)		
Transport	0.00440	-0.0832	-0.864	-0.322
	(0.893)	(0.127)	(2.218)	(0.315)
Craftsmen	-0.863	-0.0678	-2.009*	0.110
	(0.869)	(0.124)	(0.810)	(0.115)
Laborer	-1.895*	-0.175	-2.446*	0.00265
	(0.926)	(0.132)	(0.969)	(0.138)
Service	-1.074	-0.109	-2.419**	0.0381
	(0.923)	(0.131)	(0.867)	(0.123)
Non-Participant	-0.741	-0.215	-2.111**	0.0877
	(1.567)	(0.223)	(0.740)	(0.105)
Constant	150.2***	149.8***	151.4***	149.6***
	(1.228)	(0.175)	(1.122)	(0.160)
Observations	2017	2017	2047	2047
R^2	0.0381	0.257	0.0302	0.256
Fstat p-value	0.0130	0.723	0.277	0.685

Notes: This table reports the association between maternal grandparent occupation type and maternal height (Columns 1 and 2) and the SVA-optimal IV (Columns 3 and 4). Grandparent occupation types are jointly significant predictors of maternal height but are not individually or jointly significant in predicting the SVA-optimal IV. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table B.9: Association between Maternal Birth Month and Grandparent Grade Attainment

	(1) Grandmother	(2) Grandfather
February	0.146	0.0336
	(0.422)	(0.471)
March	-0.137	0.489
	(0.405)	(0.450)
April	0.109	0.164
	(0.419)	(0.464)
May	-0.0294	0.182
	(0.414)	(0.462)
June	0.302	0.889*
	(0.428)	(0.472)
July	-0.0902	-0.194
	(0.420)	(0.466)
August	0.0116	0.0569
	(0.442)	(0.491)
September	0.332	0.720
	(0.425)	(0.475)
October	-0.520	0.0535
	(0.414)	(0.462)
November	-0.141	-0.130
	(0.414)	(0.461)
December	-0.135	0.406
	(0.401)	(0.450)
Constant	4.574***	5.187***
	(0.301)	(0.337)
Observations	1912	1823
R^2	0.00352	0.00640
Fstat p-value	0.821	0.389

Notes: This table reports the association between maternal grandparent grade attainment and maternal birth month. Maternal birth months are neither individually or jointly significant in predicting grandparent grade attainment. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

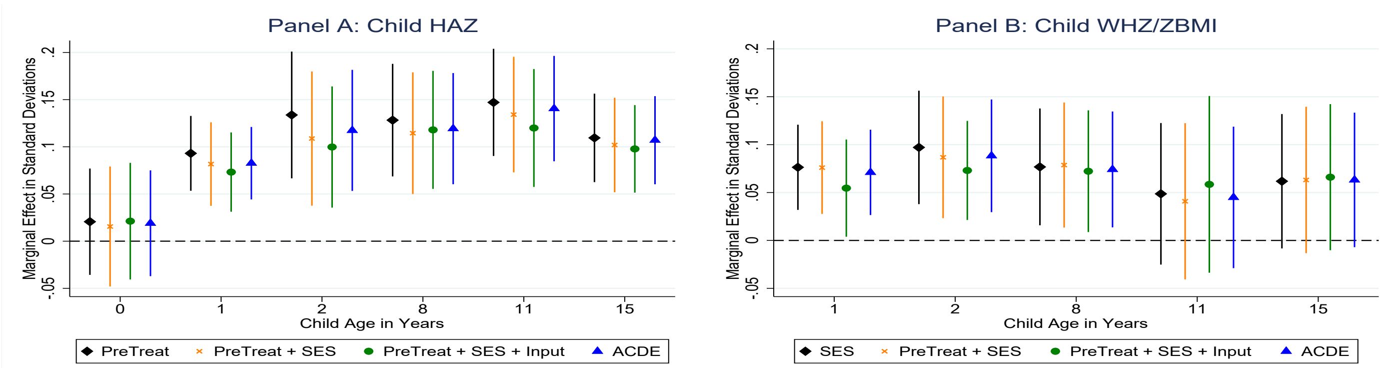
Appendix B.5 Extra Tables and Figures Supporting Main Results

Table B.10: Maternal Transmission to Child Health Controlling for Socioeconomic Characteristics—Coefficients Corresponding to Figure 2

	Birth HAZ			Birthweight		
	(1)	(2)	(3)	(4)	(5)	(6)
Mother's height (cm)	0.0206	0.0189	0.0212	30.38**	30.00**	29.56**
	(0.0287)	(0.0318)	(0.0315)	(12.55)	(13.43)	(13.71)
Observations	2988	2988	2988	2990	2990	2989
IV Effective Fstat	58.43	50.29	49.99	58.49	50.30	50.07
	Age 1 HAZ			Age 1 WHZ		
	(1)	(2)	(3)	(4)	(5)	(6)
Mother's height (cm)	0.0931***	0.0754***	0.0732***	0.0764***	0.0580**	0.0546**
	(0.0202)	(0.0220)	(0.0214)	(0.0227)	(0.0264)	(0.0259)
Observations	2996	2599	2599	2980	2595	2595
IV Effective Fstat	64.20	55.06	54.91	59.12	54.34	54.30
	Age 2 HAZ			Age 2 WHZ		
	(1)	(2)	(3)	(4)	(5)	(6)
Mother's height (cm)	0.134***	0.100***	0.0998***	0.0971***	0.0728***	0.0716***
	(0.0343)	(0.0327)	(0.0328)	(0.0302)	(0.0266)	(0.0259)
Observations	2604	2461	2461	2606	2462	2462
IV Effective Fstat	45.40	36.44	36.32	45.79	37.33	37.23
	Age 8 HAZ			Age 8 ZBMI		
	(1)	(2)	(3)	(4)	(5)	(6)
Mother's height (cm)	0.128***	0.118***	0.118***	0.0768**	0.0731**	0.0723**
	(0.0304)	(0.0323)	(0.0319)	(0.0311)	(0.0329)	(0.0324)
Observations	2210	2209	2205	2210	2209	2205
IV Effective Fstat	34.02	32.05	35.29	34.02	32.05	35.29
	Age 11 HAZ			Age 11 ZBMI		
	(1)	(2)	(3)	(4)	(5)	(6)
Mother's height (cm)	0.147***	0.124***	0.120***	0.0487	0.0346	0.0585
	(0.0290)	(0.0300)	(0.0319)	(0.0377)	(0.0430)	(0.0471)
Observations	2133	2133	2016	2133	2133	2016
IV Effective Fstat	32.99	28.93	24.77	32.99	28.93	24.77
	Age 15 HAZ			Age 15 ZBMI		
	(1)	(2)	(3)	(4)	(5)	(6)
Mother's height (cm)	0.109***	0.101***	0.0978***	0.0618*	0.0609	0.0660*
	(0.0239)	(0.0251)	(0.0237)	(0.0358)	(0.0378)	(0.0389)
Observations	2045	2038	2038	2045	2038	2038
IV Effective Fstat	23.36	21.65	19.58	23.36	21.65	19.58
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes
SES Controls	No	Yes	Yes	No	Yes	Yes
Parent Input Controls	No	No	Yes	No	No	Yes

Notes: This table reports the marginal effects, estimated by Equation 4, of instrumented maternal height on child HAZ and WFZ/ZBMI. The instrument used is the SVA-opimal IV. Point estimates correspond to those reported in Figure 2 in the main text. Columns 1 and 4 correspond to the baseline estimates reported in Figure 1, Columns 2 and 4 correspond to estimates from Equation 4 including only socioeconomic controls, and Columns 3 and 6 correspond to estimates from Equation 4 including both socioeconomic and parental input controls. See Sections IV.A and V.A and Table 3 for details. Olea and Pfluefer effective F-statistics are reported. Clustered standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Figure B.15: Comparison of Conditional Marginal Effect with ACDE of Maternal Height on Child Height and Weight Outcomes across Ages—Using Maternal Education as Mediator



Notes: This figure reports the results of sequential g-estimation using maternal education minus the sample median of maternal education as the mediator. Corresponding coefficients are reported in Appendix Table B.11. Birthweight and all other controls are treated as "intermediate confounders." Black diamonds correspond to a regression with only pretreatment controls included. Orange x's include the pretreatment controls and the mediator of mother's education (with the sample median subtracted). Green circles include all pretreatment controls, the mediator, and all socioeconomic and parental input controls. Blue triangles represent the estimated ACDE of instrumented maternal height on demediated child health. See Section V.A in the main text and Appendix E for details.

Table B.11: Comparison of Conditional Marginal Effect with ACDE of Mother Height on Child Height and Weight Outcomes Using Maternal Education as the Mediator

	Age 0 HAZ				Birthweight			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Baseline	Including Mediator	Including Mediator & Controls	ACDE	Baseline	Including Mediator	Including Mediator & Controls	ACDE
Mother's height (cm)	0.0206	0.0155	0.0212	0.0190	30.38**	30.00**	29.85**	29.65**
	(0.0287)	(0.0324)	(0.0315)	(0.0286)	(12.55)	(13.97)	(13.78)	(12.62)
Observations	2988	2988	2988	2988	2990	2988	2988	2988
	Age 1 HAZ				Age 1 WHZ			
Mother's height (cm)	0.0931***	0.0817***	0.0444**	0.0826***	0.0764***	0.0760***	0.0381	0.0710***
	(0.0202)	(0.0226)	(0.0205)	(0.0196)	(0.0227)	(0.0247)	(0.0272)	(0.0227)
Observations	2996	2996	2593	2996	2980	2980	2589	2980
	Age 2 HAZ				Age 2 WHZ			
Mother's height (cm)	0.134***	0.109***	0.0815**	0.117***	0.0971***	0.0868***	0.0567**	0.0883***
	(0.0343)	(0.0363)	(0.0321)	(0.0327)	(0.0302)	(0.0324)	(0.0269)	(0.0300)
Observations	2604	2604	2457	2604	2606	2602	2455	2602
	Age 8 HAZ				Age 8 ZBMI			
Mother's height (cm)	0.128***	0.114***	0.107***	0.119***	0.0768**	0.0787**	0.0535	0.0741**
	(0.0304)	(0.0329)	(0.0335)	(0.0300)	(0.0311)	(0.0333)	(0.0362)	(0.0309)
Observations	2210	2210	2202	2210	2210	2210	2202	2210
	Age 11 HAZ				Age 11 ZBMI			
Mother's height (cm)	0.147***	0.134***	0.111***	0.140***	0.0487	0.0409	0.0407	0.0449
	(0.0290)	(0.0312)	(0.0347)	(0.0285)	(0.0377)	(0.0416)	(0.0522)	(0.0377)
Observations	2133	2133	2013	2133	2133	2133	2013	2133
	Age 15 HAZ				Age 15 ZBMI			
Mother's height (cm)	0.109***	0.102***	0.0813***	0.107***	0.0618*	0.0631	0.0543	0.0632*
	(0.0239)	(0.0256)	(0.0263)	(0.0238)	(0.0358)	(0.0390)	(0.0435)	(0.0358)
Observations	2045	2045	2035	2045	2045	2045	2035	2045

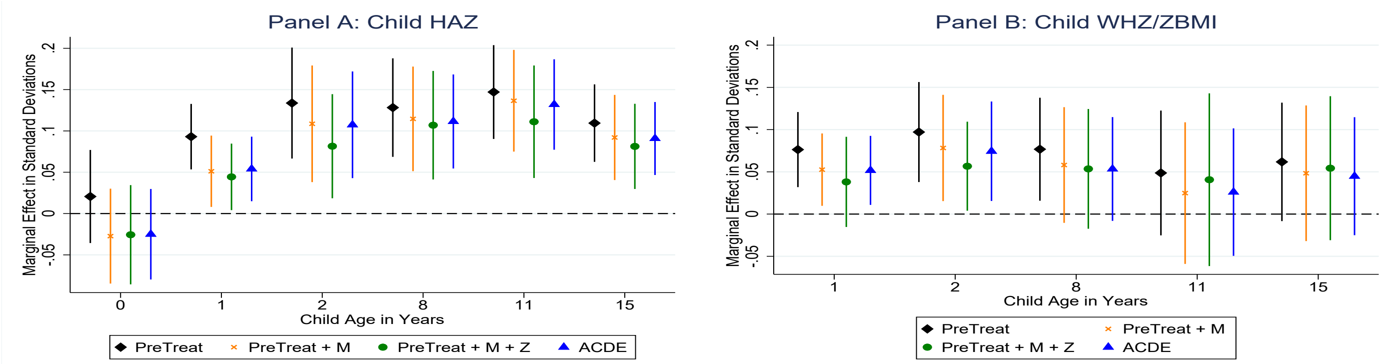
Notes: This table reports the results of sequential g-estimation using maternal education minus the sample median of maternal education as the mediator. Point estimates correspond to those plotted in Figure B.15. Columns 1 and 5 report our estimates including only pretreatement controls. Columns 2 and 6 include the mediator of mother's education (minus the median) in addition to all pretreatment controls. Columns 3 and 7 include the mediator, birthweight, and all pretreatment, socioeconomic, and parental input controls. Columns 4 and 8 report the ACDE of instrumented maternal height on demediated child health. See Section V.A in the main text and Appendix E for details. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table B.12: Transmission of Maternal Height to Child Health, Controlling for Socioeconomic Characteristics and Birthweight—Coefficients Corresponding to Figure 3

	Panel A: Child Height Outcomes					
	(1) Birth HAZ	(2) Age 1 HAZ	(3) Age 2 HAZ	(4) Age 8 HAZ	(5) Age 11 HAZ	(6) Age 15 HAZ
Mother's height (cm)	-0.0256 (0.0306)	0.0444** (0.0205)	0.0815** (0.0321)	0.107*** (0.0335)	0.111*** (0.0347)	0.0813*** (0.0263)
Birth Weight (grams)	0.00157*** (0.0000626)	0.000929*** (0.0000546)	0.000591*** (0.0000773)	0.000282*** (0.0000748)	0.000241** (0.0000947)	0.000318*** (0.0000762)
Observations	2988	2593	2457	2202	2013	2035
IV Effective Fstat	41.34	45.73	29.67	31.83	21.96	16.20
	Panel B: Child Weight Outcomes					
	Birth Weight	Age 1 WHZ	Age 2 WHZ	Age 8 ZBMI	Age 11 ZBMI	Age 15 ZBMI
Mother's height (cm)	29.56** (13.71)	0.0381 (0.0272)	0.0552** (0.0267)	0.0535 (0.0362)	0.0407 (0.0522)	0.0543 (0.0435)
Birth Weight (grams)		0.000573*** (0.0000565)	0.000494*** (0.0000530)	0.000344*** (0.0000911)	0.000401*** (0.000117)	0.000267** (0.000108)
Observations	2989	2589	2458	2202	2013	2035
IV Effective Fstat	50.07	44.96	30.54	31.83	21.96	16.20

Notes: This table reports the marginal effects, estimated by Equation 1, of instrumented maternal height on child HAZ (Panel A) and WFZ/ZBMI (Panel B) at each observed age. The instrument used is the SVA-opimal IV. Point estimates correspond to those reported in Figure 3 in the main text. Controls include birthweight in addition to all pretreatment, socioeconomic, and parental input controls. See Sections IV.A and V.A and Table 3 for details. Olea and Pfluefer effective F-statistics are reported. Clustered standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.11

Figure B.16: Comparison of Conditional Marginal Effect with ACDE of Maternal Height on Child Height and Weight Outcomes across Ages—Using Birthweight Mediator



Notes: This figure reports the results of sequential g-estimation using birthweight minus the sample median of birthweight as the mediator. Corresponding coefficients are reported in Appendix Table B.13. Mother's education and all other controls are treated as "intermediate confounders." Black diamonds correspond to a regression with only pretreatment controls included. Orange x's include the pretreatment controls and the mediator of birthweight (with the sample median subtracted). Green circles include all pretreatment controls, the mediator, and all socioeconomic and parental input controls. Blue triangles represent the estimated ACDE of instrumented maternal height on demediated child health. Age 0 is excluded from Panel B because birthweight cannot serve as its own mediator. See Section V.A in the main text and Appendix E for details.

Table B.13: Comparison of Conditional Marginal Effect with ACDE of Mother Height on Child Height and Weight Outcomes Using Birthweight as a Mediator

	Age 1 HAZ				Age 1 WHZ			
	(1) Baseline	(2) Including Mediator	(3) Including Mediator & Controls	(4) ACDE	(5) Baseline	(6) Including Mediator	(7) Including Mediator & Controls	(8) ACDE
Mother's height (cm)	0.0931***	0.0512**	0.0444**	0.0540***	0.0764***	0.0526**	0.0381	0.0517**
	(0.0202)	(0.0220)	(0.0205)	(0.0199)	(0.0227)	(0.0219)	(0.0272)	(0.0208)
Observations	2996	2990	2593	2990	2980	2974	2589	2974
	Age 2 HAZ				Age 2 WHZ			
Mother's height (cm)	0.134***	0.109***	0.0815**	0.107***	0.0971***	0.0783**	0.0567**	0.0744**
	(0.0343)	(0.0360)	(0.0321)	(0.0329)	(0.0302)	(0.0321)	(0.0269)	(0.0300)
Observations	2604	2599	2457	2599	2606	2597	2455	2597
	Age 8 HAZ				Age 8 ZBMI			
Mother's height (cm)	0.128***	0.115***	0.107***	0.111***	0.0768**	0.0581*	0.0535	0.0534*
	(0.0304)	(0.0323)	(0.0335)	(0.0290)	(0.0311)	(0.0349)	(0.0362)	(0.0313)
Observations	2210	2207	2202	2207	2210	2207	2202	2207
	Age 11 HAZ				Age 11 ZBMI			
Mother's height (cm)	0.147***	0.137***	0.111***	0.132***	0.0487	0.0248	0.0407	0.0260
	(0.0290)	(0.0314)	(0.0347)	(0.0279)	(0.0377)	(0.0428)	(0.0522)	(0.0385)
Observations	2133	2130	2013	2130	2133	2130	2013	2130
	Age 15 HAZ				Age 15 ZBMI			
Mother's height (cm)	0.109***	0.0921***	0.0813***	0.0908***	0.0618*	0.0483	0.0543	0.0448
	(0.0239)	(0.0263)	(0.0263)	(0.0225)	(0.0358)	(0.0410)	(0.0435)	(0.0356)
Observations	2045	2042	2035	2042	2045	2042	2035	2042

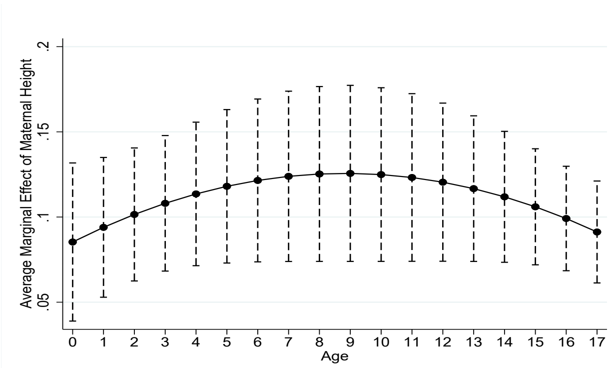
Notes: This table reports the results of sequential g-estimation using birthweight minus the sample median of birthweight as the mediator. Point estimates correspond to those plotted in Figure B.16. Columns 1 and 5 report our estimates including only pretreatement controls. Columns 2 and 6 include the mediator of birthweight (minus the median) in addition to all pretreatment controls. Columns 3 and 7 include the mediator, mother's education, and all pretreatment, socioeconomic, and parental input controls. Columns 4 and 8 report the ACDE of instrumented maternal height on demediated child health. See Section V.A in the main text and Appendix E for details. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table B.14: Nonlinearity in Marginal Effect on Child Height-for-Age with Pooled Data

	Maternal Grandfather
	(1) Maternal Height
Mother's height (cm)	0.0853***
	(0.0237)
Mother's height (cm) × Child Age	0.00912
	(0.00692)
Mother's height (cm) × Child Age × Child Age	-0.000516
	(0.000367)
Child Age	-2.450*
	(1.061)
Child Age × Child Age	0.115*
	(0.0557)
Constant	-13.19***
	(3.588)
R^2	0.194
Observations	11342

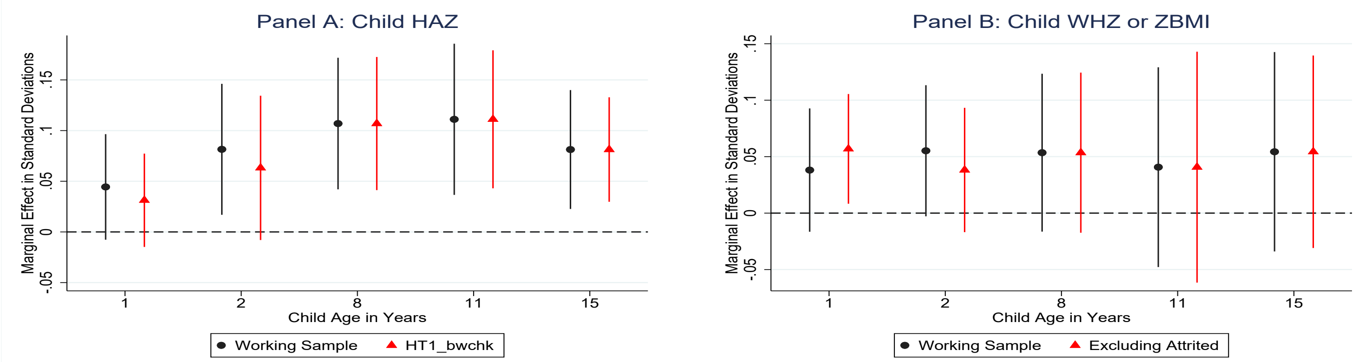
Notes: While not significant, in our main results we see a persistent inverse-U shape in the age-varying pattern of the effect of maternal health on child HAZ. For this table we pooled our data across ages and estimate the continuous effect of instrumented maternal height (cm) allowing for a quadratic interaction with age. The instrument used is our SVA-optimal IV. This table reports coefficients on instrumented maternal height and child age. Additional controls include gender, birth month fixed effects, and baseline barangay fixed effects. While the nonlinearity terms are not quite statistically significant, we nonetheless see a persistent inverse-u shape in our point estimates across ages, similar to what we find in our main results.. This can be seen in the corresponding Figure B.17. R^2 measures in the context of 2SLS do not have a clear interpretation and can fall below zero. Standard errors clustered at the mother level in parenthesis. *** p<0.01, ** p<0.05, * p<0.1

Figure B.17: Nonlinearity in Marginal Effect on Child Height-for-Age with Pooled Data



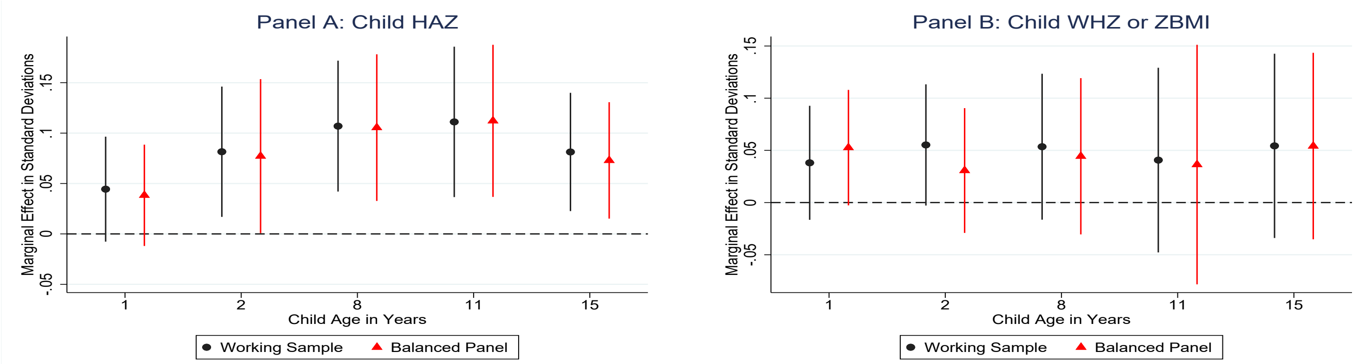
Notes: While not significant, in our main results we see a persistent inverse-U shape in the age-varying pattern of the effect of maternal health on child HAZ. For this figure we pooled our data across ages and estimate the continuous effect of instrumented maternal height (cm) allowing for a quadratic interaction with age. The instrument used is our SVA-optimal IV. This figure plots the marginal effect across ages based on coefficients reported in Table B.14. Additional controls include gender, birth month fixed effects, and baseline barangay fixed effects. While the nonlinearity terms are not quite statistically significant, we nonetheless see a persistent inverse-u shape in our point estimates across ages, similar to what we find in our main results.

Figure B.18: Replica of Figure 4 of the Marginal Effect of Maternal Health on Child Health while controlling for Socioeconomic Characteristics and Birthweight—Comparing Effects with and without Children who Attrited before Age 8



Notes: This figure plots the marginal effects, estimated by Equation 5, of instrumented maternal height (cm) on child HAZ (Panel A) and WFZ/ZBMI (Panel B) at each observed age, excluding all children that attrit from the sample before age 8. For comparison, our main results are also reported in this figure. Maternal height is instrumented using the SVA-optional IV. The black circles ("Working Sample") correspond to our main results using our working data sample, reported in Figure 2, and include birthweight and all pretreatment, socioeconomic and parental controls. The red triangles ("Excluding Atrrited") correspond to the same estimates but are estimated with a sample excluding all children who attrit before the age 8 survey. The effect of maternal height on birth weight is excluded from Panel B because its scale (grams) differs from those measured at other ages. The pattern of age-varying effects illustrated in our main results hold when excluding early attritors and may even be slightly more pronounced. Bars represent 95% confidence intervals.

Figure B.19: Replica of Figure 4 Controlling for Socioeconomic Characteristics and Birthweight—Comparing Effects with Those using the Balanced Panel



Notes: This figure plots the marginal effects, estimated by Equation 5, of instrumented maternal height (cm) on child HAZ (Panel A) and WFZ/ZBMI (Panel B), including only children that appear in all survey waves. For comparison, our main results are also reported in this figure. Maternal height is instrumented using the SVA-optional IV. The black circles ("Working Sample") correspond to our main results using our working data sample, reported in Figure 2, and include birthweight and all pretreatment, socioeconomic and parental controls. The red triangles ("Balanced Panel") correspond to the same estimates but are estimated with only the sample that are observed in every survey wave. The effect of maternal height on birth weight is excluded from Panel B because its scale (grams) differs from those measured at other ages. The pattern of age-varying effects illustrated in our main results hold when using only the balanced panel. Bars represent 95% confidence intervals.

Table B.15: Maternal Transmission to Girl and Boy Height—Coefficients Corresponding in Figure 4

	Panel A: Effect on Girl Height Outcomes				
	(1) Age 1 HAZ	(2) Age 2 HAZ	(3) Age 8 HAZ	(4) Age 11 HAZ	(5) Age 15 HAZ
Mother's height (cm)	0.0757	0.102	0.172**	0.0921**	0.122**
	(0.0528)	(0.0709)	(0.0698)	(0.0458)	(0.0540)
Observations	1216	1164	1041	975	972
IV Effective Fstat	8.341	9.709	5.208	9.300	7.161
	Panel B: Effect on Boy Height Outcomes				
	(1) Age 1 HAZ	(2) Age 2 HAZ	(3) Age 8 HAZ	(4) Age 11 HAZ	(5) Age 15 HAZ
Mother's height (cm)	0.0188	0.0630*	0.0924**	0.130***	0.0407
	(0.0236)	(0.0363)	(0.0398)	(0.0456)	(0.0348)
Observations	1377	1293	1161	1038	1063
IV Effective Fstat	37.61	20.02	23.66	8.386	11.93

Notes: This table reports the marginal effects, estimated by Equation 5, of instrumented maternal height (cm) on child HAZ at each observed age separately for girls and boys. The instrument used is the SVA-opimal IV. Point estimates correspond to those reported in Figure 4 in the main text. Controls include birthweight in addition to all pretreatment, socioeconomic, and parental input controls. See Sections IV.A and V.A and Table 3 for details. Olea and Pfluefer effective F-statistics are reported. Clustered standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table B.16: Maternal Transmission to Girl Height for Girls Likely in Childhood and Pubertal Growth—Coefficients Corresponding to Figure 5

	Panel B: Estimated Average Marginal Effects
Average Marginal Effect of Mother's Height	
Menarche 2+ yrs post 1994 survey (child growth)=0	0.0339
	(0.0518)
Menarche 2+ yrs post 1994 survey (child growth)=1	0.118*
	(0.0670)
Observations	892
	Panel A: Estimated Coefficients
Mother's height	0.0339
	(0.0518)
Age at menarche	-0.611***
	(0.0485)
Menarche 2+ yrs post 1994 survey (child growth)=1 × Mother's height	0.0845
	(0.0783)
Menarche 2+ yrs post 1994 survey (child growth)=1	-12.72
	(11.80)
Birth Weight (grams)	0.000371***
	(0.000115)
Observations	892

Notes: This table reports the marginal effects, estimated by Equation 6, of instrumented maternal height (cm) on girl HAZ at each observed age, separately for girls who are likely still in childhood growth and those likely in pubertal growth. The instrument used is the SVA-opimal IV. Point estimates correspond to those reported in Figure 5 in the main text. If a girl experiences menarche prior to two years after her age 11 interview she is considered to be in pubertal growth. Otherwise she is considered to be in childhood growth. Controls include birthweight in addition to all pretreatment, socioeconomic, and parental input controls. See Section V.A and Table 3 for details. Clustered standard errors are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table B.17: Maternal Transmission to Boy Height for Boys Likely in Childhood and Pubertal Growth—Coefficients Corresponding to Figure 6

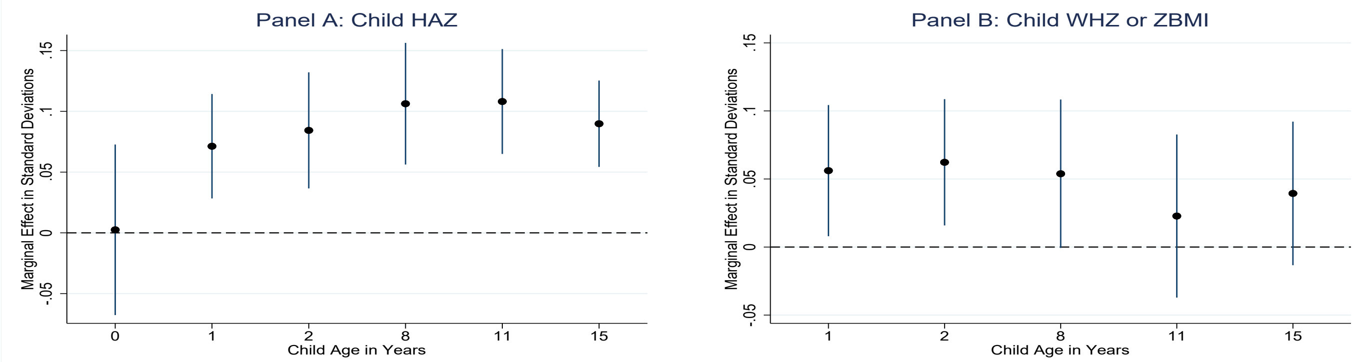
	Calculated Average Marginal Effects			
	Shaving	Voice Change	Underarm Hair	High Pubic
Mother's Height (cm)				
Begun shaving=0	0.0389 (0.0355)			
Begun shaving=1	0.0375 (0.0661)			
Voice changed=0		0.00759 (0.0910)		
Voice changed=1		0.0438 (0.0354)		
Visible underarm hair=0			0.0453 (0.0443)	
Visible underarm hair=1			0.0487 (0.0371)	
Has high level of pubic hair=0				0.00636 (0.0501)
Has high level of pubic hair=1				0.0453 (0.0402)
Observations	1056	1059	1056	1041

	Estimated Coefficients			
	Shaving	Voice Change	Underarm Hair	High Pubic
Mother's Height (cm)	0.0389 (0.0355)	0.00759 (0.0910)	0.0453 (0.0443)	0.00636 (0.0501)
Begun shaving=1 × Mother's Height (cm)	-0.00139 (0.0622)			
Begun shaving=1	0.331 (9.393)			
Voice changed=1 × Mother's Height (cm)		0.0362 (0.0929)		
Voice changed=1		-5.386 (13.97)		
Visible underarm hair=1 × Mother's Height (cm)			0.00343 (0.0388)	
Visible underarm hair=1			-0.179 (5.872)	
Has high level of pubic hair=1 × Mother's Height (cm)				0.0390 (0.0508)
Has high level of pubic hair=1				-5.579 (7.682)
Observations	1056	1059	1056	1041

Notes: This table reports the marginal effects, estimated by Equation 6, of instrumented maternal height (cm) on girl HAZ at each observed age, separately for boys who are likely still in childhood growth and those likely in pubertal growth. Point estimates correspond to those reported in Figure 6 in the main text. The instrument used is the SVA-opimal IV. If any of the above pubertal indicators are equal to one, the boy is assumed to be in pubertal growth. Controls include birthweight in addition to all pretreatment, socioeconomic, and parental input controls. See Section V.A and Table 3 for details. Clustered standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

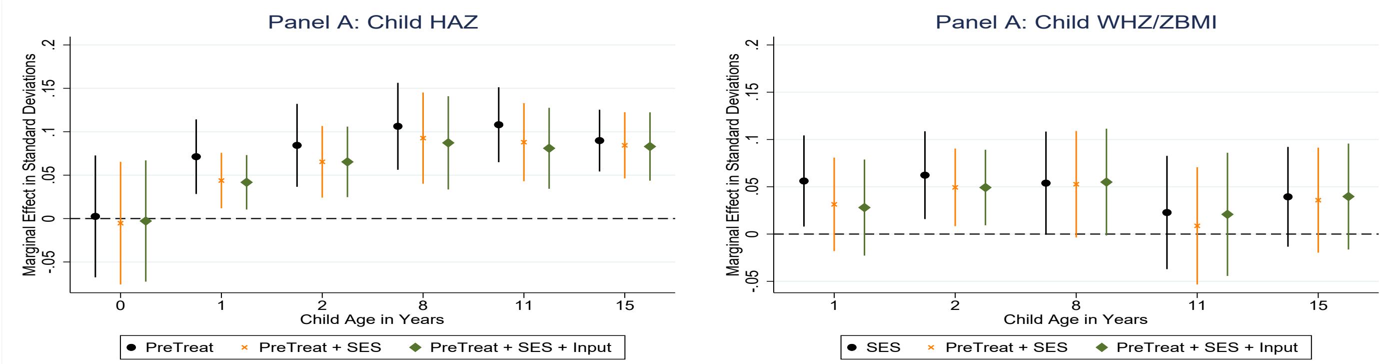
Appendix C Results with Lasso Selection of IVs

Figure C.1: Replica of Figure 1 using Lasso Chosen IVs–the Marginal Effect of Maternal Health on Child Health across Ages—Using Lasso IVs



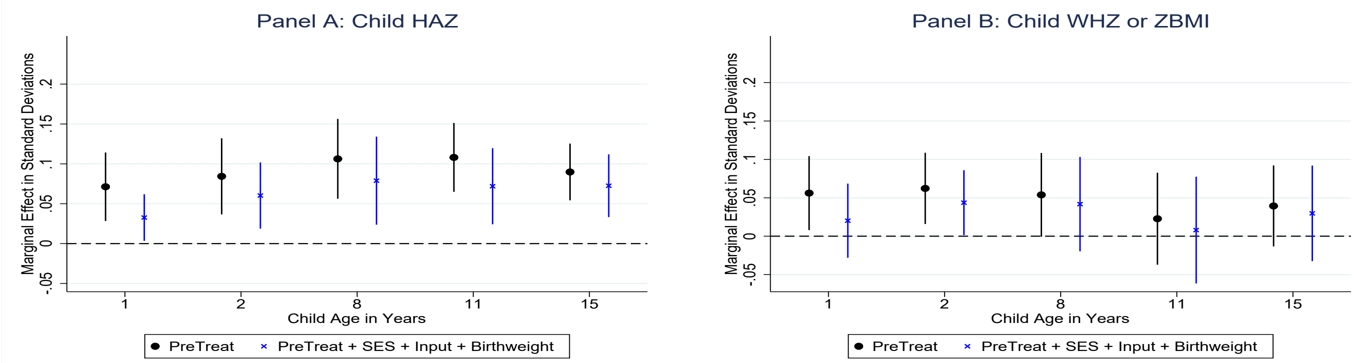
Notes: This figure plots the marginal effects, estimated by Equation 1, of instrumented maternal height on child HAZ (Panel A) and WFZ/ZBMI (Panel B) at each observed age. Maternal height is instrumented using the Lasso-chosen instruments, see Sections IV.A and IV.B for details. The estimated effect on birthweight is excluded from Panel B because its scale (grams) differs from those measured at other ages. All pretreatment controls are included, which are mother age, mother age cohort dummies, child gender, child birth month fixed effects, and baseline and current barangay fixed effects. For birth outcomes only an indicator for whether gestational age is in question is included. Bars represent 95% confidence intervals.

Figure C.2: Replica of Figure 2 using Lasso Chosen IVs–the Marginal Effect of Maternal Health on Child Height Outcomes across Ages—Controlling for Socioeconomic Characteristics and Parental Inputs—Using Lasso Chosen IVs



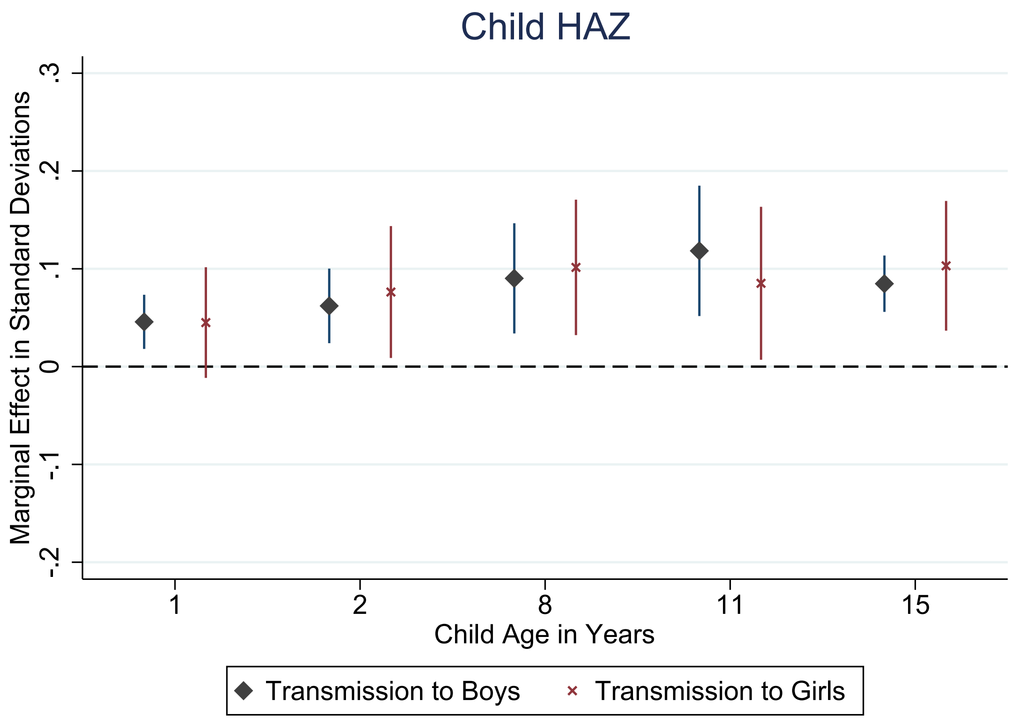
Notes: This figure plots the marginal effects, estimated by Equation 4, of instrumented maternal height on child HAZ (Panel A) and WFZ/ZBMI (Panel B) at each observed age. Maternal height is instrumented using the Lasso-chosen instruments, see Sections IV.A and IV.B for details. The black circles correspond to the baseline estimates reported in Figure C.1, orange x's correspond to estimates from Equation 4 including pretreatment controls and only socioeconomic controls (Column 1 of Table 3), and green diamonds correspond to estimates from Equation 4 including pretreatment controls and both socioeconomic and parental input controls (Column 2 of Table 3). The effect of maternal height on birthweight is excluded from Panel B because its scale (grams) differs from those measured at other ages. Bars represent 95% confidence intervals.

Figure C.3: Replica of Figure 3 using the Lasso Chosen IVs–Marginal Effect of Maternal Health on Child Health Controlling for Socioeconomic Characteristics, Parental Inputs, and Birthweight



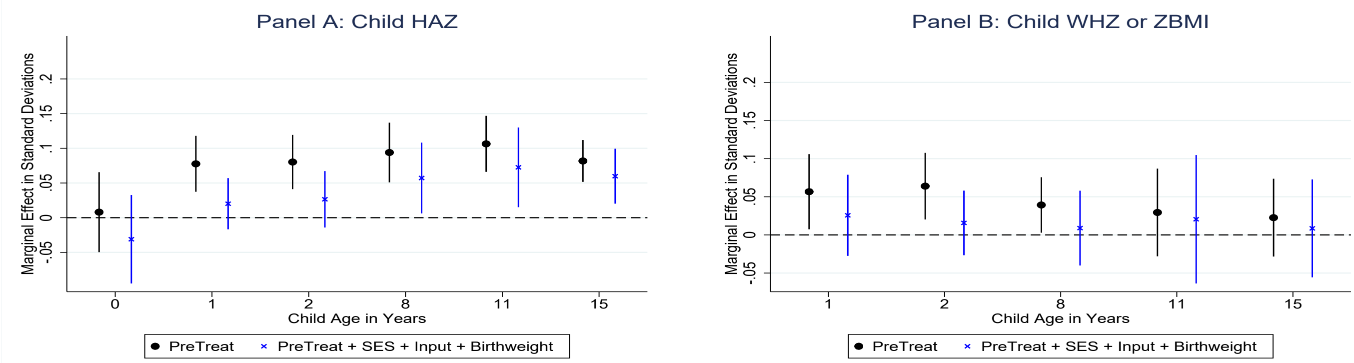
Notes: This figure plots the marginal effects, estimated by Equation 5, of instrumented maternal height on child HAZ (Panel A) and WFZ/ZBMI (Panel B) at each observed age. Maternal height is instrumented using the Lasso-chosen instruments, see Sections IV.A and IV.B for details. The black circles correspond to baseline estimates reported in Figure C.1 and include only pretreatment controls. Blue x's correspond to estimates from Equation 5 and include birthweight in addition to all pretreatment, socioeconomic, and parental input controls. See Sections IV.A and V.A and Table 3 for details. The effect of maternal height on birthweight is excluded from Panel B because its scale (grams) differs from those measured at other ages. Bars represent 95% confidence intervals.

Figure C.4: Replica of Figure 4 using the Lasso-chosen instruments—Marginal Effect of Maternal Health on Child Health for Boys and Girls Separately Controlling for Socioeconomic Characteristics and Birthweight



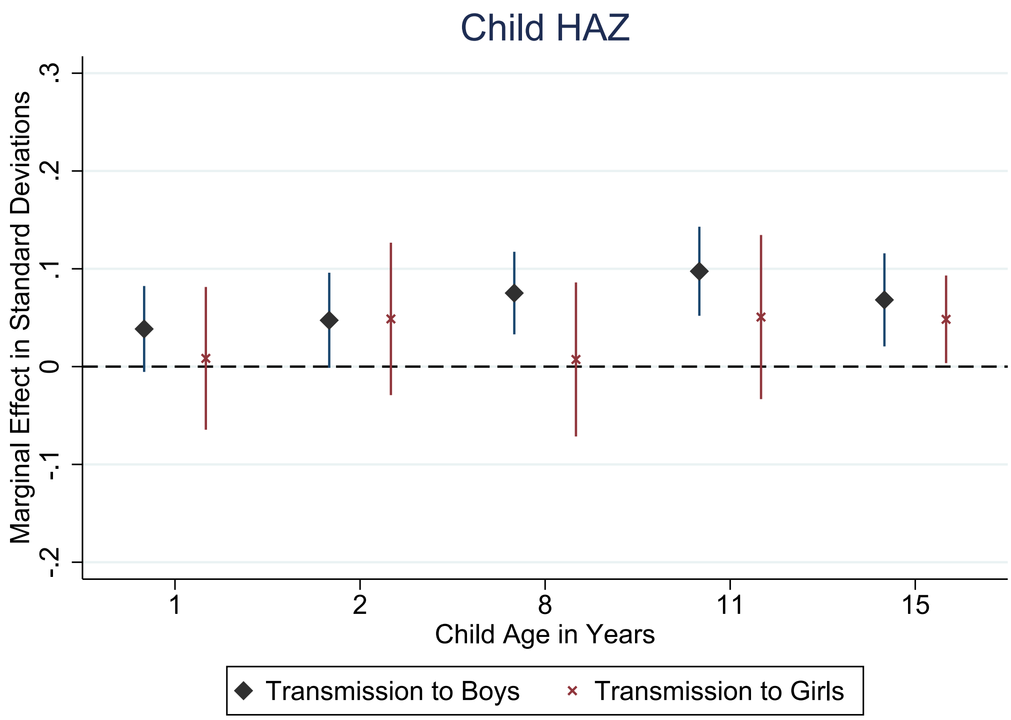
Notes: This figure plots the marginal effects, estimated by Equation 5, of instrumented maternal height on child HAZ at each observed age separately for girls (red x's) and boys (blue diamonds). Maternal height is instrumented using the Lasso-chose instruments, see Sections 4.1 and 4.2 for details. Controls include birthweight in addition to all pretreatment, socioeconomic, and parental input controls. See Sections IV.A and V.A and Table 3 for details. Bars represent 95% confidence intervals.

Figure D.3: Replica of Figure 3 using PCA-Lasso IVs—Marginal Effect of Maternal Health on Child Health Controlling for Socioeconomic Characteristics and Birthweight



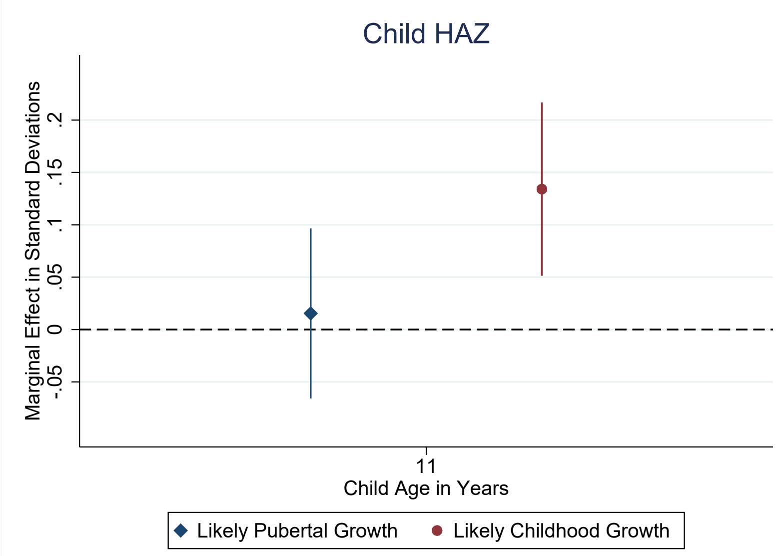
Notes: This figure plots the marginal effects, estimated by Equation 5, of instrumented maternal height on child HAZ (Panel A) and WFZ/ZBMI (Panel B) at each observed age. Maternal height is instrumented using the Lasso-chosen PCA components as instruments, see Sections 4.1 and 4.2 for details. The black circles correspond to baseline estimates reported in Figure D.1 and include only pretreatment controls. Blue x's correspond to estimates from Equation 5 and include birthweight in addition to all pretreatment, socioeconomic, and parental input controls. See Sections 4.1 and 5.1 and Table 3 for details. The effect of maternal height on birthweight is excluded from Panel B because its scale (grams) differs from those measured at other ages. Bars represent 95% confidence intervals.

Figure D.4: Replica of Figure 4 using PCA-Lasso IVs—Marginal Effect of Maternal Health on Child Health for Boys and Girls Separately Controlling for Socioeconomic Characteristics, Parental Inputs, and Birthweight



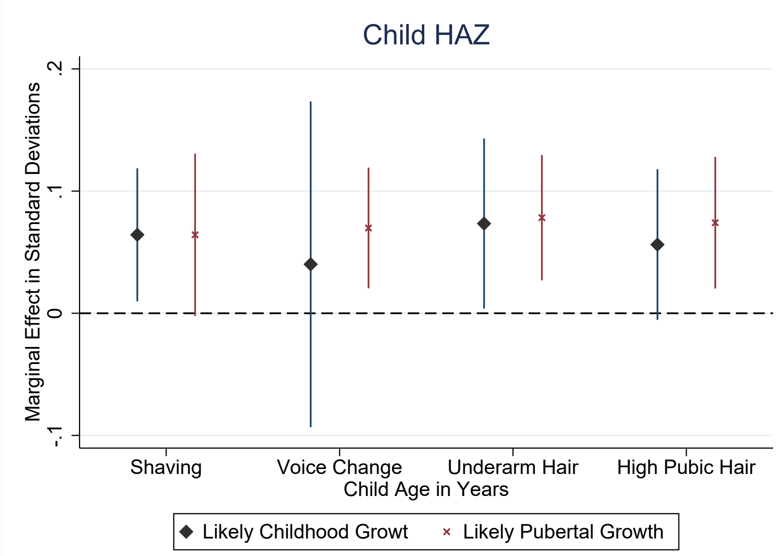
Notes: This figure plots the marginal effects, estimated by Equation 5, of instrumented maternal height on child HAZ at each observed age separately for girls (red x's) and boys (blue diamonds). Maternal height is instrumented using the Lasso-chosen PCA components as instruments, see Sections 4.1 and 4.2 for details. Controls include birthweight in addition to all pretreatment, socioeconomic, and parental input controls. See Sections 4.1 and 5.1 and Table 3 for details. Bars represent 95% confidence intervals.

Figure D.5: Replica of Figure 5 using PCA-Lasso IVs—Marginal Effect of Maternal Health on Age 11 Girl HAZ Depending on Probable Growth Stage Controlling for Socioeconomic Characteristics and Birthweight



Notes: This figure plots the marginal effects, estimated by Equation 6, of instrumented maternal height on girl HAZ at age 11, separately for girls likely in childhood (red circles) vs pubertal growth (blue diamonds). Maternal height is instrumented using the Lasso-chosen PCA components as instruments, see Sections 4.1 and 4.2 for details. Girls are assumed to be in childhood growth if menarche is still 2 or more years after their 1994 interview date. Controls include birthweight in addition to all pretreatment, socioeconomic, and parental input controls. See Sections 4.1 and 5.1 and Table 3 for details. Bars represent 95% confidence intervals.

Figure D.6: Replica of Figure 6 using PCA-Lasso IVs—Marginal Effect of Maternal Health on Age 15 Boy HAZ Depending on Probable Growth Stage Controlling for Socioeconomic Characteristics, Parental Inputs, and Birthweight



Notes: This figure plots the marginal effects, estimated by Equation 6, of instrumented maternal height on boy HAZ at age 15, separately for boys likely in childhood (red x's) vs pubertal growth (blue diamonds) based on 4 pubertal indicators. Maternal height is instrumented using the Lasso-chosen PCA components as instruments, see Sections 4.1 and 4.2 for details. Details on the pubertal indicators can be found in Section 3. Controls include birthweight in addition to all pretreatment, socioeconomic, and parental input controls. See Sections 4.1 and 5.1 and Table 3 for details. Bars represent 95% confidence intervals.

Appendix E Instrumental variables adaptation of sequential G-estimator

Consider a setting similar to that considered by both Acharya, Blackwell and Sen (2016) and Dippel et al. (2019), where treatment T impacts outcome Y directly, through a mediator M, and also through a second mediator (or observed intermediate confounders) U. Unobserved intermediate confounders V may impact treatment and both mediators, and may possibly impact the outcome. An exogenously assigned, relevant instrument for treatment exists, Z. This setting is given via Equations 1-4.

$$T = \xi_Z Z + \xi_V V + \varepsilon_T \tag{1}$$

$$U = \zeta_T T + \zeta_V V + \varepsilon_U \tag{2}$$

$$M = \varphi_T T + \varphi_U U + \varphi_v V + \varepsilon_M \tag{3}$$

$$Y = \beta_T T + \beta_U U + \beta_M M + \beta_V V + \varepsilon_Y \tag{4}$$

In our case, mother's health is T, child birthweight is M, mother's education is given by U, and child health is Y. Mothers' health might impact child health through child birthweight ($T \rightarrow M \rightarrow Y$), or through mother's education ($T \rightarrow U \rightarrow Y$). Mother's education might also influence child birthweight, though the reverse obviously cannot be true, since mother's education is determined prior to childbirth. Unobserved confounders V might include any factor which influences the human capital of both mothers and children — for instance, location within the island of Cebu, or generational family wealth. It is precisely these confounders which require us to use the SVA-based instrument Z to identify the local average treatment effect. In our analysis we additionally control for "pre-treatment controls" X, relevant controls that were assigned before treatment and therefore cannot be considered intermediate confounders. We omit these controls from Equations 1-4 for simplicity, with no loss of generality.

Neither sequential g-estimation nor the method proposed by Dippel et al. (2019) can identify direct and indirect effects when V influences Y — that is, these methods assume $\beta_v = 0$. Additionally, the method proposed by Dippel et al. (2019) requires that V influences both T and M, but also requires that V has no influence on U — that is, the method assumes $\xi_v \neq 0, \varphi_v \neq 0, \zeta_v = 0$. (The trade-off to these stringent assumptions is that the Dippel et al. (2019) method does identify direct and indirect effects in the presence of a second, unobserved confounder which may influence both M and Y as long as it does not influence T or U.)

Our adaptation of sequential g-estimation is also unable to identify direct and indirect effects when V influences Y. However, it limits the bias on these effects relative to that estimated under classic sequential g-estimation. In this way, it is an improvement over OLS-based sequential g-estimation in this setting.

Additionally, our adaptation (and OLS-based sequential g-estimation) allows V to impact U, which is critical in our setting for two reasons. First, it is unreasonable to assume that omitted confounders that impact both mothers' health and child birthweight do not impact mother's education. Second, allowing V to impact U makes U and M exchangeable, allowing us to estimate indirect effects that move through both mothers' health and birthweight. This is not possible with the method proposed by Dippel et al. (2019), which can only estimate the treatment effect that moves through M, and only if V does not impacts U. This makes our method more appropriate to this setting than the method of Dippel et al. (2019).

Four effects are of interest in our case — the direct and indirect effects that may be estimated when considering birthweight as mediator, or mother's education as mediator. When considering birthweight M as mediator, the indirect and direct effects are given by Equations 5 and 6, respectively. When considering mother's education U as mediator, the indirect and direct effects are given by Equations 7 and 8, respectively.

$$\Gamma^M \equiv \beta_M * (\varphi_T + \varphi_U * \zeta_T) \tag{5}$$

$$\Gamma^{TU} \equiv \beta_T + \beta_U * \zeta_T \tag{6}$$

$$\Gamma^U \equiv \beta_U * \zeta_T \tag{7}$$

$$\Gamma^{TM} \equiv \beta_T + \beta_M * (\varphi_T + \varphi_U * \zeta_T) \quad (8)$$

Child Birthweight (*M*) as Mediator

In what follows, we demonstrate the bias in $\hat{\Gamma}^{TU}$ under original sequential g-estimation ($\hat{\Gamma}^{TU}_{ols}$) and under our IV adaptation of sequential g-estimation ($\hat{\Gamma}^{TU}_{iv}$). Sequential g-estimation is practically done in three steps. The first two steps are identical under both methods; it is the third step that we have altered slightly.

For sequential g-estimation and our adaptation of it, the indirect effect is mechanically estimated as the difference between the average treatment effect and $\hat{\Gamma}^{TU}$. Thus, the bias in $\hat{\Gamma}^{M}_{ols}$ and $\hat{\Gamma}^{M}_{iv}$ will be identical in magnitude to the bias in $\hat{\Gamma}^{TU}_{ols}$ and $\hat{\Gamma}^{TU}_{iv}$, respectively, but of opposite sign.

Step 1: Estimate the effect of M on Y conditional on U and T (and all pre-treatment controls) through ordinary least squares regression.

$$\hat{\beta}_M = \beta_M + \beta_V * \delta_M \quad (9)$$

The bias on this estimated coefficient depends on β_V and on δ_M, where δ_M is the coefficient on M in a regression of V on T, U, and M. That is, this is classic omitted variable bias in a multivariate setting.

Step 2: Define a de-mediated outcome variable. The variable ideally defined, $\hat{Y}$, is de-mediated using β_M, as in Equation 10. However, we instead estimate $\tilde{Y}$, defined in Equation 11.

$$\hat{Y} = Y - \beta_M M = \beta_T T + \beta_U U + \beta_V V + \varepsilon_Y \tag{10}$$

$$\tilde{Y} = Y - \hat{\beta}_M M = Y - (\beta_M + \beta_V \delta_M)M = \hat{Y} - \beta_V \delta_M M \tag{11}$$

Original Step 3: Under traditional sequential g-estimation, we then estimate the effect of T on the de-mediated outcome variable through ordinary least squares

$$\begin{aligned}\widehat{\Gamma}^{TU}_{ols} &= \frac{Cov\left(\tilde{Y}, T\right)}{Var\left(T\right)} \\ &= \frac{Cov\left(\hat{Y} - \beta_V \delta_M M, T\right)}{Var\left(T\right)} \\ &= \frac{Cov\left(\hat{Y}, T\right)}{Var\left(T\right)} - \beta_V \delta_M \frac{Cov\left(M, T\right)}{Var\left(T\right)} \end{aligned} \tag{12}$$

$$\begin{aligned}\frac{Cov\left(\hat{Y}, T\right)}{Var\left(T\right)} &= \frac{Cov\left([\beta_T T + \beta_U U + \beta_V V + \varepsilon_Y], T\right)}{Var\left(T\right)} \\ &= \frac{Cov\left([\beta_T T + \beta_U(\zeta_T T + \zeta_V V + \varepsilon_U) + \beta_V V + \varepsilon_Y], T\right)}{Var\left(T\right)} \\ &= \frac{Cov\left([\beta_T T + \beta_U(\zeta_T T + \zeta_V V + \varepsilon_U) + \beta_V V + \varepsilon_Y], T\right)}{Var\left(T\right)}\end{aligned}$$

$$= \frac{Cov\left([(\beta_T + \beta_U \zeta_T)T + (\beta_V + \beta_U \zeta_V)V + \beta_U \varepsilon_U + \varepsilon_Y], T\right)}{Var\left(T\right)}$$

$$= (\beta_T + \beta_U \zeta_T) + (\beta_V + \beta_U \zeta_v)\frac{Cov\left(V, T\right)}{Var\left(T\right)} \tag{13}$$

$$\frac{Cov\left(M, T\right)}{Var\left(T\right)} = \frac{Cov\left([\varphi_T T + \varphi_U U + \varphi_v V + \varepsilon_M], T\right)}{Var\left(T\right)}$$

$$= \frac{Cov\left([\varphi_T T + \varphi_U (\zeta_T T + \zeta_v V + \varepsilon_U) + \varphi_v V + \varepsilon_M], T\right)}{Var\left(T\right)}$$

$$= \frac{Cov\left([(\varphi_T + \varphi_U \zeta_T)T + (\varphi_U \zeta_v + \varphi_V)V + \varphi_U \varepsilon_U + \varepsilon_M], T\right)}{Var\left(T\right)}$$

$$= (\varphi_T + \varphi_U \zeta_T) + (\varphi_U \zeta_v + \varphi_V)\frac{Cov\left(V, T\right)}{Var\left(T\right)} \tag{14}$$

$$\rightarrow \widehat{\Gamma}^{TU}_{ols} = \Gamma^{TU} + (\beta_V + \beta_U \zeta_v)\frac{Cov\left(V, T\right)}{Var\left(T\right)} - \beta_V \delta_M \left[(\varphi_T + \varphi_U \zeta_T) + (\varphi_U \zeta_v + \varphi_V)\frac{Cov\left(V, T\right)}{Var\left(T\right)}\right] \tag{15}$$

IV Adaptation Step 3: We instead estimate the effect of T on the de-mediated outcome variable through instrumental variables, using Z as an instrument for T. Because Z, unlike T, is orthogonal to V, the bias in this estimated coefficient is simpler than the bias in

Equation 15.

$$\widehat{\Gamma}_{iv}^{TU} = \frac{Cov\left(\tilde{Y}, Z\right)}{Cov\left(T, Z\right)}$$

$$= \frac{Cov\left(\hat{Y} - \beta_V \delta_M M, Z\right)}{Cov\left(T, Z\right)}$$

$$= \frac{Cov\left(\hat{Y}, Z\right)}{Cov\left(T, Z\right)} - \beta_V \delta_M \frac{Cov\left(M, Z\right)}{Cov\left(T, Z\right)} \tag{16}$$

$$\frac{Cov\left(\hat{Y}, Z\right)}{Cov\left(T, Z\right)} = \frac{Cov\left([\beta_T T + \beta_U U + \beta_V V + \varepsilon_Y], Z\right)}{Cov\left(T, Z\right)}$$

$$= \frac{Cov\left([\beta_T T + \beta_U (\zeta_T T + \zeta_v V + \varepsilon_U) + \beta_V V + \varepsilon_Y], Z\right)}{Cov\left(T, Z\right)}$$

$$= \frac{Cov\left([\beta_T T + \beta_U (\zeta_T T + \zeta_v V + \varepsilon_U) + \beta_V V + \varepsilon_Y], Z\right)}{Cov\left(T, Z\right)}$$

$$= \frac{Cov\left([(\beta_T + \beta_U \zeta_T) T + (\beta_V + \beta_U \zeta_v) V + \beta_U \varepsilon_U + \varepsilon_Y], Z\right)}{Cov\left(T, Z\right)}$$

$$= (\beta_T + \beta_U \zeta_T) \tag{17}$$

$$\frac{Cov\left(M, Z\right)}{Cov\left(T, Z\right)} = \frac{Cov\left([\varphi_T T + \varphi_U U + \varphi_v V + \varepsilon_M], T\right)}{Cov\left(T, Z\right)}$$

$$= \frac{Cov\big([\varphi_T T + \varphi_U(\zeta_T T + \zeta_v V + \varepsilon_U) + \varphi_v V + \varepsilon_M], Z\big)}{Cov\big(T, Z\big)}$$

$$= \frac{Cov\big([(\varphi_T + \varphi_U \zeta_T)T + (\varphi_U \zeta_v + \varphi_V)V + \varphi_U \varepsilon_U + \varepsilon_M], Z\big)}{Cov\big(T, Z\big)}$$

$$= (\varphi_T + \varphi_U \zeta_T) \tag{18}$$

$$\rightarrow \widehat{\Gamma}^{TU}_{iv} = \Gamma^{TU} - \beta_V \delta_M (\varphi_T + \varphi_U \zeta_T) \tag{19}$$

The bias shown in Equation 19 is simple to understand. The coefficients in parentheses, $(\varphi_T + \varphi_U \zeta_T)$, provide the causal effect of T on M. That is, because we were unable to fully cleanse $\tilde{Y}$ of M, $\rightarrow \widehat{\Gamma}^{TU}_{iv}$ estimates not only the effect of T on Y moving through T and U, but also the effect of T on M, weighted by $-\beta_V \delta_M$, the bias on our first stage estimate of $\hat{\beta}_M$.

The sign of this bias cannot be known, but it can be guessed at. The quantity $\varphi_T + \varphi_U \zeta_T$ can be estimated by Equation 18, i.e., by estimating the impact of T on M through instrumental variables. In our case this quantity, providing the causal impact of mother's health on child birthweight, is positive. And if V impacts both Y and M positively, or impacts both Y and M negatively, then $\beta_V \delta_M$ will be positive. It seems likely that omitted confounders will impact child birthweight in the same way that they will impact later life child health. Thus, it seems probable that the direct effect $\widehat{\Gamma}_{iv}^{TU}$ is under-estimated, while the indirect effect $\widehat{\Gamma}_{iv}^{M}$ is over-estimated as in Equation 20.

$$\widehat{\Gamma}_{iv}^{M} = \Gamma^{M} + \beta_V \delta_M (\varphi_T + \varphi_U \zeta_T) \tag{20}$$

We therefore think of our estimated indirect effect $\widehat{\Gamma}_{iv}^{TU}$ as providing a lower bound to the true direct effect that works outside of the child birthweight channel.

Mother's Education (U) as Mediator

We can similarly demonstrate the bias in $\hat{\Gamma}^{TM}$ under both original sequential g-estimation ($\hat{\Gamma}_{ols}^{TM}$) and under our IV adaptation of sequential g-estimation ($\hat{\Gamma}_{iv}^{TM}$). This is the direct effect that works outside of the maternal education channel.

Step 1: Estimate the effect of U on Y conditional on M and T (and all pre-treatment controls) through ordinary least squares regression.

$$\hat{\beta}_U = \beta_U + \beta_V * \delta_U \tag{21}$$

Here δ_U is the coefficient on U in a regression of V on T, U, and M.

Step 2: Define a de-mediated outcome variable. The variable ideally defined, $\hat{Y}$, is de-mediated using β_U, as in Equation 22. However, we instead estimate $\tilde{Y}$, defined in

Equation 23.

$$\hat{Y} = Y - \beta_U U = \beta_T T + \beta_M M + \beta_V V + \varepsilon_Y \tag{22}$$

$$\tilde{Y} = Y - \hat{\beta}_U U = Y - (\beta_U + \beta_V \delta_U)U = \hat{Y} - \beta_V \delta_U U \tag{23}$$

IV Adaptation Step 3: We estimate the effect of T on the de-mediated outcome variable through instrumental variables, using Z as an instrument for T.

$$\begin{aligned}
\widehat{\Gamma}_{iv}^{TM} &= \frac{Cov\big(\tilde{Y}, Z\big)}{Cov\big(T, Z\big)} \\
&= \frac{Cov\big(\hat{Y} - \beta_V \delta_U U, Z\big)}{Cov\big(T, Z\big)} \\
&= \frac{Cov\big(\hat{Y}, Z\big)}{Cov\big(T, Z\big)} - \beta_V \delta_U \frac{Cov\big(U, Z\big)}{Cov\big(T, Z\big)}
\end{aligned} \tag{24}$$

$$\begin{aligned}
\frac{Cov\big(\hat{Y}, Z\big)}{Cov\big(T, Z\big)} &= \frac{Cov\big([\beta_T T + \beta_M M + \beta_V V + \varepsilon_Y], Z\big)}{Cov\big(T, Z\big)} \\
&= \frac{Cov\big([\beta_T T + \beta_M(\varphi_T T + \varphi_U U + \varphi_v V + \varepsilon_M) + \beta_V V + \varepsilon_Y], Z\big)}{Cov\big(T, Z\big)} \\
&= \frac{Cov\big([\beta_T T + \beta_M(\varphi_T T + \varphi_U(\zeta_T T + \zeta_V V + \varepsilon_U) + \varphi_v V + \varepsilon_M) + \beta_V V + \varepsilon_Y], Z\big)}{Cov\big(T, Z\big)} \\
&= \frac{Cov\big((\beta_T + \beta_M \varphi_T + \beta_M \varphi_U \zeta_T)T + (\beta_M \varphi_U \zeta_V + \beta_M \varphi_V)V + \beta_M \varepsilon_M + \varepsilon_Y], Z\big)}{Cov\big(T, Z\big)}
\end{aligned}$$

$$= (\beta_T + \beta_M \varphi_T + \beta_M \varphi_U \zeta_T) \tag{25}$$

$$\frac{Cov(U,Z)}{Cov(T,Z)} = \frac{Cov([\zeta_T T + \zeta_V V + \varepsilon_U],Z)}{Cov(T,Z)} = \zeta_T \tag{26}$$

$$\rightarrow \widehat{\Gamma}_{iv}^{TM} = \Gamma^{TM} - \beta_V \delta_U \zeta_T \tag{27}$$

$$\rightarrow \widehat{\Gamma}_{iv}^{U} = \Gamma^{U} + \beta_V \delta_U \zeta_T \tag{28}$$

The sign of this bias can again be guessed at. The quantity ζ_T can be estimated by Equation 26, i.e., by estimating the impact of T on U through instrumental variables. In our case this quantity, providing the causal impact of mother's health on mother's education, is positive. If V impacts both Y and U positively, or impacts both Y and U negatively, then $\beta_V \delta_U$ will be positive. It seems likely — though we cannot be sure — that omitted confounders will impact child birthweight in the same way that they will impact mother's education. Thus, it seems probable that the direct effect $\widehat{\Gamma}_{iv}^{TM}$ is underestimated, while the indirect effect $\widehat{\Gamma}_{iv}^{U}$ is overestimated.