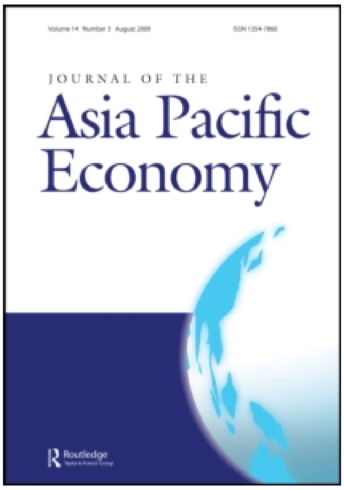


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# The link between infant mortality and child nutrition in India: is there any evidence of a gender bias?

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# The link between infant mortality and child nutrition in India: is there any evidence of a gender bias?

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In this paper, using the 1998–1999 National Family Health Survey data-set from India, we study whether there are gender differentials in infant mortality and child nutrition. Our analysis finds no evidence of gender differentials in survival probability. However, conditional upon surviving the first year, girls are found to have poorer height-for-age outcomes. There are also significant regional differences in both survival probabilities and nutritional outcomes. We show that the height-for-age *z*-score is significantly lower for higher birth-order children (later-born children), and the effect is monotonically increasing. Finally, parental education and household wealth have statistically significant effects on both survival outcomes and child nutrition.

**Keywords:** infant mortality; nutritional outcomes; gender bias; India

**JEL classifications:** O12, I21, C25

## 1. Introduction

The existence of discrimination against girls, the resulting excess female child mortality and adverse sex ratios for females in India has been well documented in the literature (see Sen and Sengupta 1983 and Das Gupta 1987). The starkest manifestation of the lack of gender equality is the phenomenon of 'missing women', the term coined by Amartya Sen in a now classic article in the *New York Review of Books* (Sen 1990), to describe the observation that the proportion of women in South Asia is lower than what would be expected if women were not discriminated against. Studies have attributed this to gender discrimination against the girl child after birth through discriminatory intra-household resource allocations particularly in terms of food, nutrition and medical care (see Bardhan 1988, Behrman 1988, Harriss 1999). A common pattern flowing through all these studies from India is that there is a strong son preference in the Indian society, which manifests itself in the form of discrimination against the female child in the allocation of food and health resources.[1] This in turn is believed to lead to excess female infant and child mortality rates.

If this argument is correct, then we must also observe poor health and nutritional status of girls relative to boys. This last observation, however, has not been supported empirically. For example, studies by Basu (1989, 1993), Pelletier (1998) and Mishra *et al*. (1999) find no evidence of any gender discrimination in nutrition, even in those Indian states where there is excess female infant mortality and low sex ratios for females. These studies suggest that the link between malnutrition and gender bias is not so clear-cut.

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These findings not only contradict the long-held view that the female disadvantage in child health is greater in regions where infant mortality rates and sex ratios at birth are adverse for females but also contrasts with research on child mortality that attribute the excess female child mortality primarily to malnutrition in children. Udry (1997) argues that the reason for this contradiction is sample truncation: girls have been so discriminated against in the first place that they have died. Rose (1999) terms this phenomenon as differential mortality selection. Both authors argue that for the selected sample, we should not expect to find any evidence of gender difference in nutrition.

The aim of this paper is to use the nationally representative National Family Health Survey (NFHS) data from India to examine if there are gender differences in child nutrition, contingent on the child having survived the first year. It is important to note that our estimations control for some but not all of the mortality selection. For example, it is possible for a girl child to survive to her first birthday but die between the ages of one and five years. It is also possible that a female child who has survived despite the discrimination may be weaker than a comparative male child who has not faced any discrimination and may have poor nutritional outcomes. Finally, although prenatal testing of a child's gender was banned by a Government of India legislation in 1994, evidence suggests that the law has not been rigorously enforced (Sudha and Rajan 1999). An examination of issues relating to sex-selective abortions is however beyond the scope of this study, as our focus is on the survival probabilities and nutritional outcomes of children that were born alive. We acknowledge that sex-selective abortions might have a downward bias on the number of girls that are born alive, so it is likely that these surviving girls are more valued and may therefore get better access to food, nutrition and health care. However, due to data constraints, we are unable to explore these possibilities.

We use the two anthropometric measures height-for-age and weight-for-height as our measure of child nutritional outcomes. In an influential paper, Waterlow *et al*. (1997) established that a child's height-for-age and weight-for-height *z*-scores are good indicators of his/her nutritional status. The height-for-age *z*-score (HAZ) measures the child's height according to age, expressed in standard deviations from the mean of the reference population. The measures are standardised for age and sex. The reference population used in this study is the commonly used US National Center for Health Statistics (NCHS) standard, which is recommended for use by the World Health Organisation (WHO). This indicator reflects the cumulative effects of growth deficiency and is used to measure long-term nutrition. Children with low height-for-age are said to be *stunted*. The weight-for-height *z*-score (WHZ) measures the child's weight according to height, again in standard deviations from the mean of the (same) reference population. This indicator has been used to monitor the growth of children and is typically regarded as a measure of short-term rather than long-term health status. Children with low weight-for-height are said to be *wasted*.

We find no evidence of sample selection, thus rejecting the sample truncation hypothesis. Other interesting results include (1) a lack of gender differences in survival outcomes, (2) better HAZ outcomes for boys relative to girls indicating better long-term nutrition for boys, (3) a lack of gender discrimination in WHZ indicating no gender differences in short-term nutritional status, (4) more adverse survival and nutritional outcomes for children from the poorer wealth quintiles and finally, (5) large regional differences in all three outcomes (infant mortality, HAZ and WHZ).

## 2. Data and selected descriptive statistics

The data for our analysis come from the National Family and Health Survey 1998–1999 (NFHS-II) for India. The NFHS is the second in a series of surveys conducted with

Table 1. Descriptive statistics.

| Variables | Full sample ($N = 16,652$) | Male ($N = 8706$) | Female ($N = 7946$) |
|---|---|---|---|
| Alive | 0.91 | 0.92 | 0.91 |
| Male | 0.52 | | |
| Twin | 0.02 | 0.02 | 0.02 |
| Birth-order | | | |
| 1 | 0.27 | 0.27 | 0.28 |
| 2 | 0.25 | 0.25 | 0.25 |
| 3 | 0.18 | 0.18 | 0.18 |
| 4 | 0.11 | 0.12 | 0.11 |
| 5 | 0.07 | 0.07 | 0.07 |
| 6 or higher | 0.11 | 0.11 | 0.11 |
| Low birthweight | 0.26 | 0.25 | 0.28 |
| Age of mother at birth | | | |
| <20 | 0.24 (0.43) | 0.24 (0.43) | 0.25(0.43) |
| 20–24 | 0.39 (0.49) | 0.39 (0.49) | 0.39 (0.49) |
| 25–29 | 0.23 (0.42) | 0.23 (0.42) | 0.23 (0.42) |
| 30–34 | 0.09 (0.29) | 0.09 (0.29) | 0.09 (0.29) |
| 35–39 | 0.03 (0.18) | 0.03 (0.18) | 0.03 (0.18) |
| 40 or higher | 0.01 (0.10) | 0.01 (0.09) | 0.01 (0.10) |
| Home delivery | 0.66 | 0.66 | 0.65 |
| HAZ score | −1.94 (1.69) | −1.91 (1.67) | −1.97 (1.72) |
| WHZ score | −0.86 (1.25) | −0.86 (1.25) | −0.86 (1.25) |
| Mother | | | |
| No education | 0.65 | 0.64 | 0.66 |
| Literate, but less than middle school completion | 0.17 | 0.17 | 0.18 |
| Middle school complete | 0.08 | 0.09 | 0.07 |
| High school complete and higher | 0.10 | 0.11 | 0.09 |
| Able to keep money aside | 0.49 | 0.50 | 0.49 |
| Needs permission to visit market | 0.81 | 0.81 | 0.81 |
| Needs permission to visit friend | 0.85 | 0.85 | 0.85 |
| Has say on health care | 0.45 | 0.45 | 0.45 |
| Use ORS | 0.29 | 0.29 | 0.30 |
| Heard of ORS | 0.30 | 0.31 | 0.29 |
| BMI category of mother | | | |
| Underweight | 0.42 | 0.42 | 0.41 |
| Normal weight | 0.56 | 0.55 | 0.56 |
| Overweight | 0.02 | 0.02 | 0.02 |
| Obese | 0.01 | 0.01 | 0.01 |
| Father | | | |
| No education | 0.34 | 0.34 | 0.35 |
| Literate, but less than middle school completion | 0.25 | 0.25 | 0.25 |
| Middle school complete | 0.15 | 0.15 | 0.15 |
| High school complete and higher | 0.26 | 0.27 | 0.26 |
| Father’s occupation | | | |
| Manual worker | 0.32 | 0.33 | 0.32 |
| Office worker | 0.064 | 0.07 | 0.06 |
| Hindu | 0.84 | 0.84 | 0.85 |
| Muslim | 0.11 | 0.11 | 0.11 |
| SC/ST/OBS | 0.66 | 0.66 | 0.67 |
| Main source of drinking water: piped | 0.09 | 0.09 | 0.09 |
| Wealth quintile | | | |
| 1 | 0.27 | 0.26 | 0.27 |
| 2 | 0.25 | 0.25 | 0.25 |
| 3 | 0.23 | 0.23 | 0.23 |

Table 1. Descriptive statistics. *(Continued)*

| Variables | Full sample ($N = 16{,}652$) | Male ($N = 8706$) | Female ($N = 7946$) |
|---|---|---|---|
| 4 | 0.18 | 0.19 | 0.17 |
| 5 | 0.08 | 0.08 | 0.07 |
| Sub-centre in village | 0.06 | 0.06 | 0.06 |
| Primary health centre in village | 0.02 | 0.02 | 0.02 |
| Community health centre in village | 0.05 | 0.05 | 0.04 |
| Government dispensary in village | 0.03 | 0.03 | 0.03 |
| Government hospital in village | 0.01 | 0.01 | 0.01 |
| Private clinic in village | 0.03 | 0.03 | 0.03 |
| Private hospital in village | 0.04 | 0.04 | 0.03 |
| Andhra Pradesh | 0.04 | 0.04 | 0.05 |
| Assam | 0.03 | 0.04 | 0.03 |
| Bihar | 0.13 | 0.13 | 0.13 |
| Gujarat | 0.04 | 0.04 | 0.04 |
| Haryana | 0.04 | 0.05 | 0.04 |
| Himachal Pradesh | 0.04 | 0.04 | 0.04 |
| Karnataka | 0.05 | 0.04 | 0.05 |
| Kerala | 0.03 | 0.03 | 0.03 |
| Madhya Pradesh | 0.11 | 0.11 | 0.11 |
| Maharashtra | 0.04 | 0.04 | 0.04 |
| Orissa | 0.07 | 0.07 | 0.07 |
| Punjab | 0.03 | 0.03 | 0.04 |
| Rajasthan | 0.12 | 0.12 | 0.12 |
| Tamil Nadu | 0.04 | 0.04 | 0.04 |
| West Bengal | 0.04 | 0.04 | 0.04 |
| Uttar Pradesh | 0.14 | 0.13 | 0.14 |

financial support from the United States Agency for International Development (USAID), with additional funding from UNICEF.

The survey was administered nationwide to ever-married females aged 15–49 years. It is a household survey and contains detailed information on household structure, labour market participation, asset ownership, health and educational characteristics for all the household members. The sample size for each state was specified in terms of a target number of completed interviews with eligible women. A uniform sample design was adopted in all the states. In each state, the rural sample was selected in two stages: the selection of primary sampling units (PSUs), which are villages, with probability proportional to population size (PPS) at the first stage, followed by the random selection of households within each PSU in the second stage.

Our analysis is based on data for 16,652 rural children born in the five years prior to the survey.[2] The sample is restricted to children up to 60 months of age at the time of the survey to ensure that there is compatibility between the infant mortality figures and our nutrition measures, which are only available for children under the ages of 60 months.[3] Finally, we restrict our analysis to the 15 major states in the country.

Table 1 presents the summary statistics for the variables used in our analysis. Of the 16,652 children in our sample who were born (alive), 91.24% survived to their first birthday. Girls constitute approximately 48% of our full sample, with boys making up the remaining 52% of the sample. Table 2 presents descriptive statistics for the three main variables of interest, infant mortality, WHZ and HAZ. From Table 3, we note that there is no evidence of gender differences in the survival outcomes of infants: 90.90% of girls and 91.55% of

Table 2. Descriptive statistics of mortality, HAZ and WHZ.

| | All children | Boys | Girls | *t*-test of gender difference |
|---|---|---|---|---|
| Proportion alive | 0.9124 | 0.9155 | 0.9090 | −1.4703 |
| Average HAZs | −1.9386 | −1.9077 | −1.9727 | −2.3656* |
| Average WHZs | −0.8633 | −0.8625 | −0.8643 | −0.0872 |

*Significance at the 5% level.

boys survive the first year, but the differences are not statistically significant. For the sample of children who have survived the first year, we find some evidence of gender bias – the average HAZ is significantly lower for girls. There are, however, no gender differences in the case of WHZ.[4] The raw descriptive statistics suggest that stunting (and long-term poor nutrition) is a bigger problem for girls.

To obtain some overall aggregates on child nutrition, we follow Kassouf and Senauer (1996) and categorise children according to the following classification of malnutrition: (1) severe: $z$-score $< -3$; (2) moderate: $z$-score lies in the interval $(-3, -2)$; (3) mild: $z$-score lies in the interval $(-2, -1)$; (4) normal: $z$-score $> -1$. The $z$-scores have an important advantage over other simple measures of height and weight. They are less sensitive to changes at the extremes of distributions of these variables, and they facilitate comparisons across measures that often exhibit different variability in terms of units of measurement. The relevant statistics are presented in Table 3. When we disaggregate by gender, we observe that 26.98% of girls and 24.90% of boys have HAZ in the normal range [the gender difference is statistically significant ($t = -2.9191$, $p = 0.000$)], while 3.17% of girls and 3.22% of boys have WHZ in the normal range (the gender difference is not statistically significant).

We also computed the kernel density estimates of the $z$-scores of the children who survived to their first birthday, and these are presented in Figures 1 (HAZ) and 2 (WHZ). Not surprisingly, the estimates are skewed to the left, indicating that the mass of the distribution lies to the left of −1. This implies that the majority of the children are not in the normal range. In Figures 3 and 4, we present the kernel density estimates for the sample

Table 3. Comparison of HAZ and WHZ measures.

| *z*-score interval | Degree of malnutrition | Boys | Girls | *t*-test of gender difference |
|---|---|---|---|---|
| **HAZs** | | | | |
| < −3 | Severe | 0.2790 | 0.2653 | 1.9055* |
| (−3, −2) | Moderate | 0.2437 | 0.2344 | 1.3380 |
| (−2, −1) | Mild | 0.2882 | 0.2305 | −0.3343 |
| −1 | Normal | 0.2490 | 0.2698 | −2.9191** |
| **WHZs** | | | | |
| < −3 | Severe | 0.5193 | 0.5113 | 0.9902 |
| (−3, −2) | Moderate | 0.3133 | 0.3242 | −1.4457 |
| (−2, −1) | Mild | 0.1351 | 0.1328 | 0.4267 |
| −1 | Normal | 0.0322 | 0.0317 | 0.1895 |

*Significance at the 10% level; **significance at the 1% level.

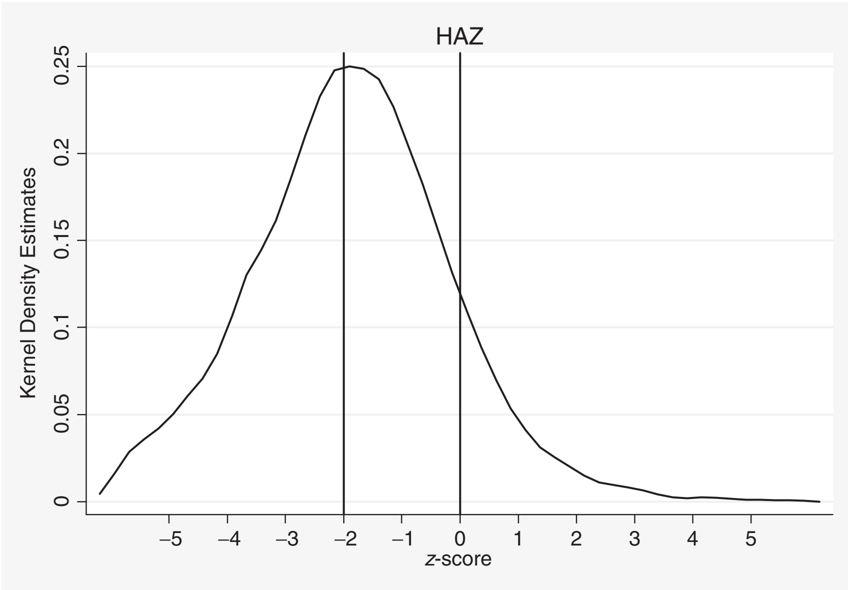


Figure 1. Kernel density estimates of HAZs.

stratified by the gender of the child. Using a Kolmogorov–Smirnov test for the equality of distributions, we reject the null hypothesis of equality of distributions of HAZ by gender ($p = 0.034$) but cannot reject the null hypothesis of equality of distributions of WHZ by gender ($p = 0.934$).

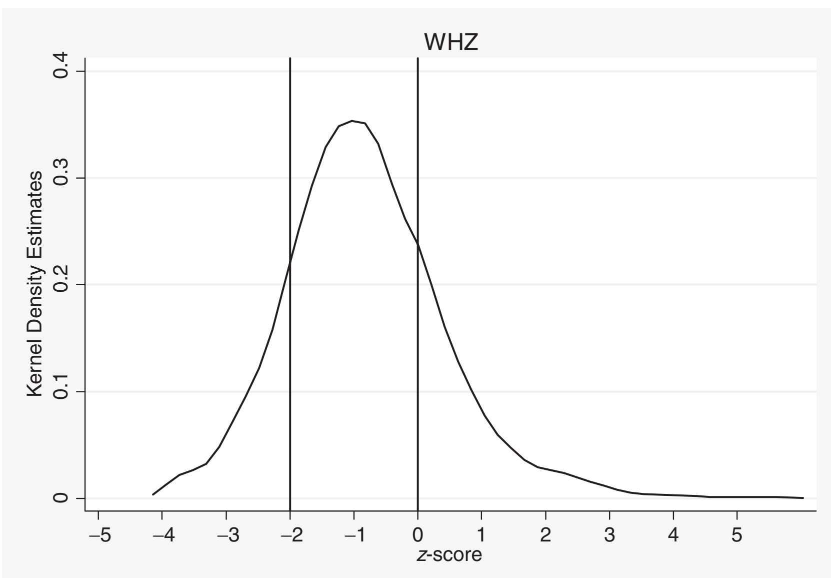


Figure 2. Kernel density estimates of WHZs.

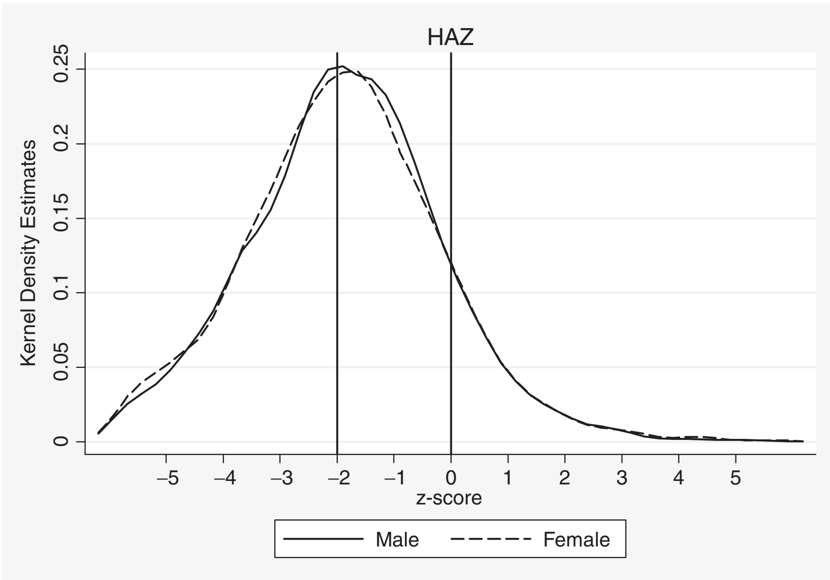


Figure 3. Kernel density estimates of HAZ, by gender.

Much has been written on the regional variation in patterns of gender discrimination in India (see, for example, Dyson and Moore 1983, Kishor 1993, Murthi *et al*. 1995, Pande 2003). These studies have identified a north–south divide where they observe relatively higher female mortality in the north-western states of Uttar Pradesh, Bihar, Punjab and

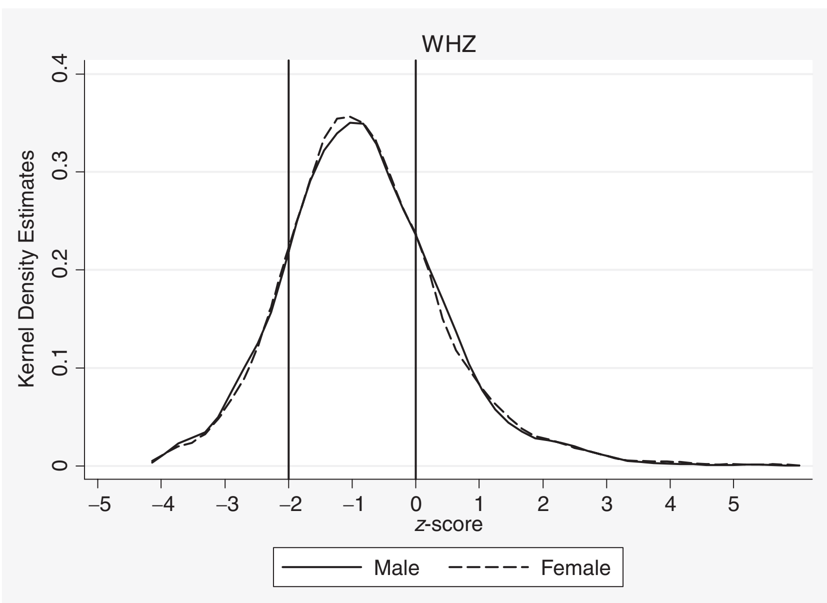


Figure 4. Kernel density estimates of WHZ, by gender.

Haryana relative to the south-eastern states of Andhra Pradesh, Kerala, Karnataka, Tamil Nadu and West Bengal. Furthermore, data from the Indian census show that although the sex ratios for under six years are biased against females in all the Indian states and territories, the problem is particularly severe in the northern Indian states of Punjab, Haryana, Gujarat and Himachal Pradesh, where for every 1000 boys under six years of age, the number of girls are 790 (Punjab), 820 (Haryana), 870 (Gujarat) and 890 (Himachal Pradesh) respectively (see Census of India 2001). This discrimination appears not to be linked to economic factors. For example, while Punjab is the richest Indian state, it also has the worst sex ratio for children in the zero- to six-year age category, where there are only 790 females for every 1000 males.

We begin examining these issues by presenting some broad descriptive statistics on regional variations in infant mortality rates (Table 4) and nutritional measures of children (Table 5). Both mortality rates and nutritional attainment vary significantly across the different states of the country. From Table 5, we observe that the proportion of children surviving past the first birthday is 0.87 in the case of Uttar Pradesh, compared with 0.98 in the case of Kerala. Similarly, according to Table 4, the trend across all the Indian states is to have a higher proportion of boys rather than girls surviving, with a few exceptions. The female disadvantage in survival is particularly large in the states of Uttar Pradesh, Punjab, Rajasthan and Andhra Pradesh.

There are similar variations in the average HAZ and WHZ across the different states. From Table 5, it is noteworthy that the poorest HAZ outcomes are for children from the four northern states of Uttar Pradesh, Bihar, Madhya Pradesh and Haryana, where children fall in the category of moderate malnutrition. In terms of WHZ, however, the children in the northern states fare somewhat better than their South Indian counterparts, and the degree of malnutrition is less adverse and is in the mild category generally. In terms of differences across individual states, the average HAZ ranges from $-1.11$ standard deviations (*SD*) for Kerala to $-2.22$ *SD* for Uttar Pradesh, while the average WHZ ranges from $-0.07$ *SD* for Sikkim to $-1.26$ *SD* for Orissa. In Table 4, we present the gender-differentiated counterparts of the descriptive statistics presented in Table 5. In general, conditional on surviving past the first year, the average HAZ and WHZ are lower for girls, although the differences are typically not statistically significant.



## 3. Econometric methodology

As described previously, our analysis focuses on two distinct but related issues. The first is the probability of a child surviving the first year, and second, contingent upon survival, we examine the factors affecting child nutritional measures.

In stage 1 of the analysis, we estimate a probit model for child survival: the dependent variable is $s_i = 1$ if the child has survived the first year and 0 otherwise. Child survival beyond the first year depends on a set of child-specific ($I_1$), parental/household ($H_1$), community ($V_1$) characteristics and health inputs ($C_1$).

In the second stage, we estimate the nutritional status of children aged 12–60 months.[5] The nutritional status of a child ($z_i$) is determined by a biological health production technology:

$$z_i = f(I_2, H_2, C_2, \vartheta_i), \tag{1}$$

where $I_2$ and $H_2$ denote a set of individual and parental/household characteristics that affect child health (including relative bargaining power of the mother), $C_2$ is a vector of health

Table 4. Regional variations of infant mortality by gender.

| | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | Sample size | Proportion alive | Height-for-age | Weight-for-height | Sample size | Proportion alive | Height-for-age | Weight-for-height |
| Andhra Pradesh | 370 | 0.9459 | −1.7371 | −0.7054 | 365 | 0.9205 | −1.7601 | −0.7763 |
| Assam | 316 | 0.8892 | −2.0970 | −0.0778 | 259 | 0.8919 | −1.9656 | −0.0503 |
| Bihar | 1110 | 0.8973 | −2.1120 | −0.9106 | 1004 | 0.9114 | −2.1736 | −0.9275 |
| Gujarat | 342 | 0.9269 | −1.8519 | −0.8457 | 327 | 0.9235 | −1.9291 | −0.9085 |
| Haryana | 397 | 0.9244 | −2.0362 | −0.3098 | 332 | 0.9217 | −2.2562 | −0.2280 |
| Himachal Pradesh | 333 | 0.9550 | −1.8685 | −0.7973 | 283 | 0.9717 | −1.5602 | −0.8032 |
| Karnataka | 388 | 0.9407 | −1.4778 | −1.0976 | 373 | 0.9357 | −1.6085 | −1.1450 |
| Kerala | 229 | 0.9782 | −1.1771 | −0.8609 | 210 | 0.9905 | −1.0430 | −0.6698 |
| Madhya Pradesh | 965 | 0.8819 | −2.0377 | −1.0681 | 913 | 0.8806 | −2.1634 | −1.0888 |
| Maharashtra | 373 | 0.9544 | −1.7458 | −1.2204 | 322 | 0.9410 | −1.6838 | −1.2450 |
| Orissa | 604 | 0.9189 | −1.7054 | −1.2865 | 531 | 0.9040 | −1.7346 | −1.2252 |
| Punjab | 302 | 0.9536 | −1.5978 | −0.3231 | 279 | 0.9176 | −1.8506 | −0.3542 |
| Rajasthan | 1087 | 0.9126 | −2.1671 | −0.8362 | 971 | 0.8929 | −2.2087 | −0.7842 |
| Tamil Nadu | 346 | 0.9624 | −1.3442 | −1.0958 | 338 | 0.9497 | −1.2698 | −0.9662 |
| West Bengal | 382 | 0.9450 | −1.7658 | −0.9690 | 337 | 0.9644 | −2.0976 | −0.9573 |
| Uttar Pradesh | 1162 | 0.8744 | −2.1404 | −0.7626 | 1102 | 0.8575 | −2.3004 | −0.8306 |
| Total | 8706 | 0.9155 | −1.9077 | −0.8625 | 7946 | 0.9090 | −1.9727 | −0.8643 |

Table 5. Regional variations in nutritional measures.

| State | Sample size | Proportion alive | Height-for-age | Weight-for-height |
|---|---|---|---|---|
| Andhra Pradesh | 735 | 0.9333 | −1.7484 | −0.7401 |
| Assam | 575 | 0.8904 | −2.0377 | −0.0654 |
| Bihar | 2114 | 0.9040 | −2.1415 | −0.9187 |
| Gujarat | 669 | 0.9253 | −1.8895 | −0.8763 |
| Haryana | 729 | 0.9232 | −2.1362 | −0.2726 |
| Himachal Pradesh | 616 | 0.9627 | −1.7255 | −0.8001 |
| Karnataka | 761 | 0.9382 | −1.5417 | −1.1208 |
| Kerala | 439 | 0.9841 | −1.1125 | −0.7689 |
| Madhya Pradesh | 1878 | 0.8813 | −2.0988 | −1.0781 |
| Maharashtra | 695 | 0.9482 | −1.7173 | −1.2317 |
| Orissa | 1135 | 0.9119 | −1.7189 | −1.2581 |
| Punjab | 581 | 0.9363 | −1.7168 | −0.3377 |
| Rajasthan | 2058 | 0.9033 | −2.1865 | −0.8120 |
| Tamil Nadu | 684 | 0.9561 | −1.3077 | −1.0322 |
| West Bengal | 719 | 0.9541 | −1.9230 | −0.9634 |
| Uttar Pradesh | 2264 | 0.8662 | −2.2175 | −0.7954 |
| Total | 16,652 | 0.9124 | −1.9386 | −0.8633 |

inputs and $\vartheta_i$ is a random error term. Assuming a linear functional form, we have

$$z_i = \alpha X_{2i} + \vartheta_i, \tag{2}$$

where $X_2 = [I_2, H_2, C_2]$ are as defined above. We estimate Equation (2) after accounting for sample selection, i.e. estimate $z_i$ for $s_i = 1$ using the Heckman two-step methodology where $z_i$ in Equation (2) is assumed to be continuous.

The above discussion treats nutrition as a continuous variable. However, as discussed in the previous section, the extent of the malnutrition can also be analysed using the categories described by Kassouf and Senauer (1996). Accordingly, we divide the child anthropometric measures (height-for-age and weight-for-height) into three categories: (1) severe, (2) moderate and (3) normal and mild which are combined into one category. As a robustness check, we also estimate an ordered probit model for the three categories described above, again explicitly taking into account mortality selection. In Table 6, we present the ordered probit estimation results. We also estimated ordinary least squares (OLS) regressions for nutritional status (where we do not take into account the selection issue) and random effect generalised least squares (GLS) estimates to account for mother level unobserved heterogeneity (some mothers in our sample have multiple children in the sample). They are qualitatively quite similar to the Heckman two-step estimates that we present here and are available on request.

Both child survival and child nutritional outcomes depend on a set of child-specific, parental, household demographic and economic characteristics and a set of health inputs. The variables used in our analysis are briefly described below.

### 3.1. *Explanatory variables*

Household-specific characteristics such as household size, the education levels and occupation of the parents and socio-economic characteristics will influence the probability of an infant dying and also their nutrition. We control for the socio-economic status of

Table 6. Selection-corrected ordered probit estimates of HAZ and WHZ categories.

| | HAZ | | | WHZ | | |
|---|---|---|---|---|---|---|
| | Full sample | Male | Female | Full sample | Male | Female |
| Constant | 1.5476*** | 1.4824*** | 1.6997*** | 2.6716*** | 2.6064*** | 2.7108*** |
| | (0.0971) | (0.1324) | (0.1401) | (0.1013) | (0.1376) | (0.1525) |
| Male | 0.0494*** | | | −0.0007 | | |
| | (0.0181) | | | (0.0188) | | |
| Birth-order | | | | | | |
| 2 | −0.0133 | −0.0016 | −0.0213 | −0.0372 | −0.0086 | −0.0739* |
| | (0.0260) | (0.0360) | (0.0380) | (0.0268) | (0.0371) | (0.0391) |
| 3 | −0.0268 | 0.0089 | −0.0806* | −.0008 | 0.0454 | −0.0605 |
| | (0.0291) | (0.0403) | (0.0431) | (0.0300) | (0.0409) | (0.0451) |
| 4 | −0.0110 | −0.0224 | −0.0010 | −0.0575* | −0.0020 | −0.1265** |
| | (0.0333) | (0.0461) | (0.0485) | (0.0347) | (0.0482) | (0.0503) |
| 5 | −0.0328 | −0.0484 | −0.0285 | −0.0058 | 0.0549 | −0.0728 |
| | (0.0384) | (0.0535) | (0.0557) | (0.0408) | (0.0573) | (0.0587) |
| 6 | −0.0336 | 0.0257 | −0.1102** | −0.0789** | −0.0155 | −0.1578*** |
| | (0.0346) | (0.0472) | (0.0522) | (0.0362) | (0.0510) | (0.0521) |
| Twin | −0.3412*** | −0.2372*** | −0.4379*** | −0.0310 | −0.1239 | 0.0275 |
| | (0.0538) | (0.0828) | (0.0730) | (0.0540) | (0.0772) | (0.0780) |
| Child's age | −1.4586*** | −1.4818*** | −1.4476*** | −0.8573*** | −0.8940*** | −0.8179*** |
| | (0.0404) | (0.0562) | (0.0585) | (0.0406) | (0.0564) | (0.0594) |
| Age squared | 0.4872*** | 0.5225*** | 0.4531*** | 0.3459*** | 0.3750*** | 0.3123*** |
| | (0.0193) | (0.0268) | (0.0279) | (0.0197) | (0.0275) | (0.0287) |
| **Maternal characteristics** | | | | | | |
| Use ORS | 0.0019 | −0.0064 | 0.0144 | −0.0069 | −0.0318 | 0.0315 |
| | (0.0229) | (0.0321) | (0.0330) | (0.0241) | (0.0340) | (0.0345) |
| Heard of ORS | 0.0225 | 0.0260 | 0.0195 | −0.0121 | −0.0398 | 0.0267 |
| | (0.0244) | (0.0336) | (0.0360) | (0.0250) | (0.0346) | (0.0367) |
| Literate, but less than middle school completion | 0.1095*** | 0.1313*** | 0.0806** | 0.0309 | 0.0256 | 0.0396 |
| | (0.0276) | (0.0380) | (0.0406) | (0.0286) | (0.0400) | (0.0414) |

(Continued on next page)

Table 6. Selection-corrected ordered probit estimates of HAZ and WHZ categories. *(Continued)*

| | HAZ | | | WHZ | | |
|---|---|---|---|---|---|---|
| | Full sample | Male | Female | Full sample | Male | Female |
| Middle school complete | 0.1699*** | 0.1896*** | 0.1284** | 0.0617 | 0.0583 | 0.0633 |
| | (0.0387) | (0.0521) | (0.0585) | (0.0406) | (0.0547) | (0.0616) |
| High school complete and higher | 0.2886*** | 0.3346*** | 0.2346*** | 0.1575*** | 0.1467** | 0.1787*** |
| | (0.0422) | (0.0573) | (0.0630) | (0.0434) | (0.0591) | (0.0648) |
| Not working | 0.0363* | 0.0371 | 0.0361 | 0.0830*** | 0.1250*** | 0.0402 |
| | (0.0219) | (0.0305) | (0.0316) | (0.0225) | (0.0315) | (0.0326) |
| **Paternal characteristics** | | | | | | |
| Literate, but less than middle school completion | 0.0627** | 0.1138*** | 0.0059 | 0.0218 | −0.0067 | 0.0558 |
| | (0.0246) | (0.0341) | (0.0360) | (0.0258) | (0.0359) | (0.0378) |
| Middle school complete | 0.1120*** | 0.1520*** | 0.0715 | 0.0789** | 0.0958** | 0.0654 |
| | (0.0303) | (0.0422) | (0.0439) | (0.0318) | (0.0450) | (0.0452) |
| High school complete and higher | 0.1120*** | 0.1590*** | 0.0644 | 0.0571* | 0.0225 | 0.1017** |
| | (0.0303) | (0.0428) | (0.0432) | (0.0316) | (0.0451) | (0.0446) |
| Occupation | | | | | | |
| Manual worker | −0.0100 | −0.0137 | −0.0102 | −0.0092 | −0.0367 | 0.0244 |
| | (0.0202) | (0.0278) | (0.0297) | (0.0212) | (0.0293) | (0.0309) |
| Office worker | 0.0424 | 0.0380 | 0.0439 | −0.0815** | −0.0956* | −0.0681 |
| | (0.0398) | (0.0537) | (0.0605) | (0.0408) | (0.0549) | (0.0625) |
| **Household characteristics** | | | | | | |
| Household size | −0.0033 | −0.0040 | −0.0020 | 0.0023 | 0.0007 | 0.0019 |
| | (0.0030) | (0.0042) | (0.0042) | (0.0031) | (0.0044) | (0.0044) |
| Number of children < 5 years | −0.0031 | 0.0075 | −0.0177 | −0.0010 | −0.0079 | 0.0191 |
| | (0.0118) | (0.0163) | (0.0169) | (0.0121) | (0.0167) | (0.0175) |
| Hindu | −0.0989* | −0.1528** | −0.0271 | −0.0689 | −0.0311 | −0.1086 |
| | (0.0535) | (0.0719) | (0.0812) | (0.0572) | (0.0761) | (0.0883) |
| Muslim | −0.1605*** | −0.2008** | −0.0937 | −0.1298** | −0.1255 | −0.1310 |
| | (0.0603) | (0.0810) | (0.0914) | (0.0645) | (0.0864) | (0.0984) |
| SC/ST/OBS | −0.1227*** | −0.1483*** | −0.0906*** | −0.0731*** | −0.0686** | −0.0773** |
| | (0.0220) | (0.0303) | (0.0323) | (0.0233) | (0.0319) | (0.0346) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Wealth quintile | | | | | | |
| 1 | −0.4230*** | −0.3413*** | −0.5204*** | −0.3145*** | −0.3581*** | −0.2667*** |
| | (0.0494) | (0.0678) | (0.0733) | (0.0532) | (0.0726) | (0.0789) |
| 2 | −0.3682*** | −0.3072*** | −0.4447*** | −0.2553*** | −0.2761*** | −0.2359*** |
| | (0.0472) | (0.0644) | (0.0703) | (0.0505) | (0.0681) | (0.0761) |
| 3 | −0.3060*** | −0.2613*** | −0.3665*** | −0.1938*** | −0.1696*** | −0.2223*** |
| | (0.0443) | (0.0607) | (0.0657) | (0.0474) | (0.0641) | (0.0710) |
| 4 | −0.1822*** | −0.1429** | −0.2376*** | −0.1355*** | −0.1122* | −0.1710** |
| | (0.0421) | (0.0570) | (0.0635) | (0.0450) | (0.0598) | (0.0690) |
| Mother allowed to set money aside | 0.0306 | 0.0712*** | −0.0159 | −0.0076 | 0.0073 | −0.0247 |
| | (0.0193) | (0.0268) | (0.0281) | (0.0201) | (0.0280) | (0.0294) |
| Mother needs permission to visit market | 0.0303 | 0.0399 | 0.0117 | −0.0436 | −0.0411 | −0.0502 |
| | (0.0361) | (0.0501) | (0.0527) | (0.0373) | (0.0516) | (0.0545) |
| Mother needs permission to visit friends | −0.0688* | −0.0273 | −0.1114** | 0.0149 | 0.0370 | −0.0146 |
| | (0.0384) | (0.0538) | (0.0553) | (0.0389) | (0.0541) | (0.0567) |
| Mother has say in health | 0.0436** | 0.0214 | 0.0673** | −0.0117 | −0.0147 | −0.0039 |
| | (0.0192) | (0.0264) | (0.0281) | (0.0201) | (0.0277) | (0.0294) |
| **State** | | | | | | |
| Andhra Pradesh | 0.3396*** | 0.3019*** | 0.3848*** | 0.0521 | 0.0598 | 0.0592 |
| | (0.0536) | (0.0747) | (0.0772) | (0.0576) | (0.0789) | (0.0854) |
| Assam | 0.1234** | 0.0676 | 0.1900** | 0.1517*** | 0.1702** | 0.1449 |
| | (0.0519) | (0.0712) | (0.0766) | (0.0572) | (0.0787) | (0.0841) |
| Bihar | 0.1152*** | 0.0853 | 0.1490*** | −0.2316*** | −0.2132*** | −0.2391*** |
| | (0.0365) | (0.0502) | (0.0533) | (0.0379) | (0.0528) | (0.0549) |
| Gujarat | 0.1162** | 0.1601** | 0.0684 | −0.2310*** | −0.1781** | −0.2810*** |
| | (0.0537) | (0.0768) | (0.0761) | (0.0551) | (0.0784) | (0.0789) |
| Haryana | −0.0477 | 0.0026 | −0.1020 | 0.3033*** | 0.2464*** | 0.3741*** |
| | (0.0530) | (0.0708) | (0.0805) | (0.0593) | (0.0793) | (0.0898) |
| Himachal Pradesh | 0.0266 | −0.1126 | 0.1830** | −0.3444*** | −0.3437*** | −0.3339*** |
| | (0.0560) | (0.0762) | (0.0831) | (0.0572) | (0.0776) | (0.0857) |

*(Continued on next page)*

Table 6. Selection-corrected ordered probit estimates of HAZ and WHZ categories. *(Continued)*

| | HAZ | | | WHZ | | |
|---|---|---|---|---|---|---|
| | Full sample | Male | Female | Full sample | Male | Female |
| Karnataka | 0.5134*** | 0.4805*** | 0.5455*** | −0.4194*** | −0.4223*** | −0.4035*** |
| | (0.0523) | (0.0757) | (0.0731) | (0.0531) | (0.0740) | (0.0773) |
| Kerala | 0.6257*** | 0.5444*** | 0.7215*** | −0.2096*** | −0.2317** | −0.1569 |
| | (0.0681) | (0.0918) | (0.1029) | (0.0738) | (0.1016) | (0.1084) |
| Madhya Pradesh | 0.1344*** | 0.1414*** | 0.1335** | −0.2855*** | −0.2931*** | −0.2778*** |
| | (0.0385) | (0.0532) | (0.0561) | (0.0400) | (0.0554) | (0.0581) |
| Maharashtra | 0.2992*** | 0.2096*** | 0.3990*** | −0.4840*** | −0.4713*** | −0.4879*** |
| | (0.0561) | (0.0773) | (0.0819) | (0.0567) | (0.0784) | (0.0825) |
| Orissa | 0.4240*** | 0.3995*** | 0.4541*** | −0.4445*** | −0.4686*** | −0.4084*** |
| | (0.0458) | (0.0626) | (0.0677) | (0.0470) | (0.0650) | (0.0685) |
| Punjab | 0.0951 | 0.0676 | 0.1325 | 0.1597** | 0.1326 | 0.2084 |
| | (0.0668) | (0.0943) | (0.0962) | (0.0741) | (0.1003) | (0.1111) |
| Rajasthan | 0.0758** | 0.0718 | 0.0774 | −0.0323 | −0.0640 | 0.0078 |
| | (0.0369) | (0.0507) | (0.0544) | (0.0399) | (0.0557) | (0.0577) |
| Tamil Nadu | 0.6438*** | 0.5945*** | 0.6964*** | −0.3522*** | −0.3469*** | −0.3402*** |
| | (0.0581) | (0.0793) | (0.0868) | (0.0576) | (0.0809) | (0.0835) |
| West Bengal | 0.2853*** | 0.3490*** | 0.2216*** | −0.1899*** | −0.2278*** | −0.1311 |
| | (0.0540) | (0.0757) | (0.0778) | (0.0583) | (0.0806) | (0.0848) |
| $\mu$ (1) | 0.7167*** | 0.7124*** | 0.7266*** | 0.9208*** | 0.9239*** | 0.9205*** |
| | (0.0110) | (0.0150) | (0.0162) | (0.0193) | (0.0267) | (0.0284) |
| $\mu$ (2) | 1.4528*** | 1.4523*** | 1.4644*** | 1.9080*** | 1.8973*** | 1.9269*** |
| | (0.0143) | (0.0195) | (0.0210) | (0.0214) | (0.0296) | (0.0318) |
| $\rho$ (u,e) | 0.0856 | −0.0187 | 0.1088 | −0.02675 | 0.0026 | 0.0742 |
| | (0.0899) | (0.1251) | (0.1242) | (0.091893) | (0.1330) | (0.1213) |

Note: Superscripts ***, ** and * denote significance at 1%, 5% and 10% levels respectively.

the household by including an array of variables such as the child's geographical location (state or province of residence), religion and caste. Other household characteristics such as mother's age, parental education levels, father's occupation and mother's employment status are also controlled for.

We describe in detail some of the explanatory variables used in the analysis below. To get a measure of the household's economic status, we include the wealth index that was available in the data-set. The wealth index is divided into population quintiles, with the lowest quintile representing the poorest 20% and the highest quintile representing the wealthiest 20% of households (see Filmer and Pritchett 2001). These wealth quintiles have the advantage of providing a reasonably reliable measure of the household's economic status and are less likely to be affected by the transitory nature of labour income. From Table 1, we note that the lower wealth quintiles are overrepresented with 27% of the children in the full sample belonging to the poorest wealth quintile, and only 7.4% of the children in our sample coming from the richest wealth quintile.



Similarly, the role of maternal autonomy variables on child nutrition outcomes is well established in the literature. Previous literature (see, for example, studies by Strauss 1990, Strauss and Thomas 1995, Behrman 1998, and Glewwe 2000) has focused on the manner in which an improvement in maternal control over resources can improve child health outcomes. In these studies, maternal economic status is typically assessed using variables relating to the ability of the mother to control household economic resources such as ownership of assets, jewellery and indirectly through educational attainment and labour market status. Bloom *et al*. (2001) point out that in traditional societies, women's autonomy (their rights, power and status) is often defined in the domestic sphere. Our data-set contains several questions on maternal decision-making power in the household with regard to the mother's physical mobility and ability to access economic resources. Despite the qualitative nature of these questions, they provide us with reasonable proxies for maternal decision-making power in the household.

Specifically, respondents were asked several questions on who had the final say on a range of issues relating to household decision-making, whether the respondent needs permission to visit her friends and relatives, whether the respondent needs permission to visit the market and whether the respondent had a say in the health care decisions relating to her children. From Table 1, it is evident that maternal autonomy is low in this sample, with 81% of the mothers in the full sample needing permission to visit the market and 85% needing permission to visit friends. Only 49% of the mothers are allowed to keep money aside.

Maternal education levels are similarly low, with approximately 65% of the mothers in the full sample having no education. Previous empirical research on the influence of maternal work on child nutrition is ambiguous. See, for example, Leslie (1988) and Glick and Sahn (1995) on the issue of whether maternal employment improves or worsens child nutrition. Since rural women typically have a low attachment to the formal sector labour markets, in our empirical estimations, we include a dummy variable taking on a value of one if the mother is not working and zero otherwise.

The child-specific variables included in the analysis are the child's sex, age, whether the child was part of a twin, a subjective measure of the child's birthweight, the number of children in the household under the age of five years and the child's birth-order. Sahn and Alderman (1997) argue that the determinants of nutritional outcomes are age dependent and attributable to biological factors, and a failure to take into account these cohort-specific influences is likely to give biased estimates. To capture age-specific effects on nutrition, we divide the sample into five age cohorts: 6–12 months (the base case), 13–24 months, 25–36 months, 37–49 months and 50–60 months.

Similarly, we include a variable for whether the child is a twin, since that is likely to affect the probability of survival and also lead to competition for food and health resources, which may impact on nutritional outcomes. The child's birthweight is an imprecise measure in our data-set because the birthweight measure used in the data-set relied on the mother's subjective recollection of child size (large, small or average) and was not a quantitative measure. Hence, we construct a dummy that takes on a value of one if the child was low birthweight and zero otherwise.

For birth-order, we use the absolute birth-order of each child in the household to compute six dichotomous birth-order dummy variables – second-born, third-born, fourth-born, fifth-, sixth- to tenth-born (with the first-born child being the reference category). The effect of birth-order on the probability of survival is ambiguous. On the one hand, higher birth-order (later-born) children are born to older mothers and may therefore have a higher probability of survival since the mother is likely to be more experienced and may be in a better position to deal with unexpected health problems. On the other hand, higher parity children or girls in particular may be neglected because of resource constraints and strong son preference.

We recognize that there is potential for unobserved heterogeneity with regard to the genetic factors and calorie intake of the mother during pregnancy. For example, a child's health endowments are largely unobservable to the researcher, and this could potentially lead to biased estimates because of its correlation with observed variables. This problem may be reduced by entering the health endowments of the parents. However, since the data-set contains no information on father's health, we rely on maternal health endowments [specifically the mother's body mass index (BMI)] and the child's birth-order to account for the influence of genetic factors on child health.

Finally, we also include an array of health technology variables that will affect infant mortality and child nutrition. These include dummy variables to indicate the availability of health services in the village such as whether there is a government dispensary, a government hospital in the village, a private clinic, a private hospital, a private health centre and a community health centre in the village. In our sample, approximately 66% of the children were delivered at home, and a majority of the children in our sample live in villages without access to medical facilities. For example, only 2% of the children live in villages that have a primary health centre, and only 3% of the children live in villages that have a government dispensary. The lack of medical facilities in the respondent's village does not preclude them from accessing health care facilities in nearby towns. Nonetheless, the fact that access to any type of medical facility is so low in our sample is a concern, given the high proportion of the population that lives in rural India.

We include several questions on the respondent's knowledge of health care, specifically whether the respondent has knowledge of oral rehydration salts (ORS), whether she has used ORS and whether the child was born in a hospital or at home. The use of ORS is described by the UNICEF as the best way for combating the dehydration caused by diarrhoea. In 1968, researchers in Bangladesh and India discovered that adding glucose to water and salt in the right proportions enabled the liquid to be absorbed through the intestinal wall. Therefore, a child suffering from diarrhoea could have lost fluids and salts replaced simply by drinking this solution. Since diarrhoea is a major cause of infant mortality and poor nutrition of children in developing countries, the inclusion of these variables provides us with a measure of maternal health knowledge. It is noteworthy that both knowledge and use of ORS are low in our sample. According to our descriptive statistics, only 30% of the mothers in our sample had heard of diarrhoea, and only 29% of the mothers in the sample had used ORS.

Finally, as discussed previously, regional variations in child survival outcomes between girls and boys in India are well articulated in the literature. Hence, in our estimations, we include state-level dummy variables for the 15 large states. These include the states of Andhra Pradesh, Kerala, Tamil Nadu, Karnataka (South), Uttar Pradesh, Rajasthan, Punjab, Haryana, Himachal Pradesh (North), Assam, Bihar, West Bengal, Orissa (East), Maharashtra and Gujarat (West).

## 4. Results

The main results of the analysis are presented in Tables 6–8. In Table 7, we present the coefficients and the marginal effects for the probit estimates for the full sample, separately for male and female children. The selection-corrected OLS estimates for HAZ and WHZ are presented in Table 8, and the ordered probit results are presented in Table 6. We first discuss the results for the Heckman model for the full sample and then proceed to the gender-differentiated estimation results. Since the ordered probit results are qualitatively similar to the OLS results, these results are discussed briefly.

### 4.1. *Probability of surviving past the first birthday*

To keep the analysis tractable, we discuss the marginal effects for the probability of a child surviving past his/her first birthday for the full sample and then for male and female children separately.

The first point to note is that the male dummy variable is not statistically significant in the selection equation. In other words, there is no evidence to support the notion of male advantage in survival probability. However, as we will see later, these aggregate results hide the important ways in which the explanatory variables affect girls and boys separately.

Our analysis indicates an important role for sibling- and child-specific characteristics. For example, in the full sample, the probability of surviving past the first birthday is statistically significant and 4.3 percentage points lower if the child is part of a twin and 2.3 percentage points lower if the child is of low birthweight.[6] We also see large, significant and negative birth-order effects, where relative to a first-born child, the probability of survival decreases monotonically for each subsequent (later-born) child. Relative to a first-born child, a child born second in the birth-order has a 3.2 percentage points lower probability of surviving to his/her first birthday, increasing to 9.9% in the case of a child born sixth or higher in the birth-order.

Despite these negative effects of being born later in the birth-order, our results also point to some positive synergies from having siblings.[7] Specifically, in our full sample results, having a greater number of children in the household under five years of age significantly improves survival probabilities by 4.9% for children. It is unclear why we observe such large coefficients – we hypothesise that there are some economies of scale, as it is possible that the mother has benefited from bringing up other young children.

Turning to the influence of parental/household characteristics, we see that while a father's educational attainment has only statistically significant effects on infant survival probabilities for those children with fathers having the highest level of education, all categories of mother's education improve survival probability for infants relative to those children whose mother has no education. For example, relative to mothers with no schooling, a child whose mother has completed at least primary schooling has a 1.2% higher probability

Table 7. Probit estimates of child survival.

| | Full sample | Marginal effect | Males | Marginal effect | Females | Marginal effect |
|---|---|---|---|---|---|---|
| Constant | 0.2893 | 0.0384 | 0.2908 | 0.0289 | 0.2605 | 0.0273 |
| | (0.1839) | | (0.2643) | | (0.2542) | |
| Male | 0.0279 | 0.0029 | | | | |
| | (0.0309) | | | | | |
| Birth-order | | | | | | |
| 2 | −0.2736*** | −0.0323 | −0.2320*** | −0.0255 | −0.3145*** | −0.0376 |
| | (0.0493) | | (0.0679) | | (0.0723) | |
| 3 | −0.4196*** | −0.0550 | −0.2277*** | −0.0256 | −0.6176*** | −0.0889 |
| | (0.0601) | | (0.0845) | | (0.0871) | |
| 4 | −0.5094*** | −0.0734 | −0.4586*** | −0.0609 | −0.5614*** | −0.0831 |
| | (0.0734) | | (0.0990) | | (0.1101) | |
| 5 | −0.4953*** | −0.0727 | −0.3541*** | −0.0451 | −0.6618*** | −0.1071 |
| | (0.0838) | | (0.1177) | | (0.1221) | |
| 6 | −0.6363*** | −0.0991 | −0.3926*** | −0.0503 | −0.8810*** | −0.1560 |
| | (0.0872) | | (0.1214) | | (0.1279) | |
| Twin | −0.4086*** | −0.0430 | −0.4226*** | −0.0421 | −0.3966*** | −0.0415 |
| | (0.0610) | | (0.0877) | | (0.0845) | |
| Low birthweight | −0.1982*** | −0.0226 | −0.1973*** | −0.0214 | −0.2064*** | −0.0233 |
| | (0.0343) | | (0.0482) | | (0.0487) | |
| Delivery at home | 0.7039*** | 0.0907 | 0.6987*** | 0.0858 | 0.7344*** | 0.0944 |
| | (0.0369) | | (0.0520) | | (0.0523) | |
| **Maternal characteristics** | | | | | | |
| Age | | | | | | |
| 20–24 | 0.1737*** | 0.0178 | 0.1279** | 0.0125 | 0.2329*** | 0.0235 |
| | (0.0443) | | (0.0617) | | (0.0640) | |
| 25–29 | 0.3656*** | 0.0330 | 0.3434*** | 0.0295 | 0.3994*** | 0.0352 |
| | (0.0611) | | (0.0851) | | (0.0888) | |
| 30–34 | 0.4586*** | 0.0357 | 0.4532*** | 0.0333 | 0.4901*** | 0.0370 |
| | (0.0812) | | (0.1127) | | (0.1181) | |
| 35–39 | 0.4137*** | 0.0317 | 0.3461** | 0.0262 | 0.4570*** | 0.0337 |
| | (0.1000) | | (0.1447) | | (0.1404) | |
| 40 and above | 0.3619** | 0.0284 | −0.0506 | −0.0052 | 0.8872*** | 0.0459 |
| | (0.1567) | | (0.1982) | | (0.2731) | |
| BMI | | | | | | |
| Overweight | −0.2266** | −0.0284 | −0.2979** | −0.0374 | −0.1344 | −0.0156 |
| | (0.1048) | | (0.1464) | | (0.1530) | |
| Obese | −1.6658*** | −0.4560 | −1.8055*** | −0.5005 | −1.6080*** | −0.4321 |
| | (0.0928) | | (0.1281) | | (0.1378) | |
| Literate, but middle school uncompleted | 0.1243** | 0.0123 | 0.0674 | 0.0065 | 0.1913*** | 0.0181 |
| | (0.0500) | | (0.0709) | | (0.0708) | |
| Middle school completed | 0.2150*** | 0.0195 | 0.2606** | 0.0217 | 0.1750 | 0.0162 |
| | (0.0759) | | (0.1044) | | (0.1104) | |
| High school completed or above | 0.3125*** | 0.0269 | 0.1650 | 0.0147 | 0.4914*** | 0.0372 |
| | (0.0905) | | (0.1176) | | (0.1507) | |
| Not working | 0.1246*** | 0.0136 | 0.1768*** | 0.0186 | 0.0821 | 0.0088 |
| | (0.0357) | | (0.0494) | | (0.0522) | |
| Use ORS | 0.1625*** | 0.0162 | 0.1779*** | 0.0167 | 0.1528*** | 0.0152 |
| | (0.0382) | | (0.0539) | | (0.0545) | |
| Heard of ORS | 0.1312*** | 0.0133 | 0.1951*** | 0.0183 | 0.0664 | 0.0068 |
| | (0.0424) | | (0.0589) | | (0.0616) | |
| **Paternal characteristics** | | | | | | |
| Literate, but niddle school uncompleted | 0.0224 | 0.0023 | 0.1354** | 0.0127 | −0.0809 | −0.0088 |
| | (0.0396) | | (0.0572) | | (0.0555) | |
| Middle school completed | 0.0696 | 0.0070 | 0.0907 | 0.0086 | 0.0509 | 0.0052 |
| | (0.0513) | | (0.0721) | | (0.0736) | |
| High school completed or above | 0.1701*** | 0.0168 | 0.1567* | 0.0147 | 0.1887** | 0.0184 |
| | (0.0552) | | (0.0784) | | (0.0772) | |

Table 7. Probit estimates of child survival. *(Continued)*

| | Full sample | Marginal effect | Males | Marginal effect | Females | Marginal effect |
|---|---|---|---|---|---|---|
| Occupation | | | | | | |
| Manual worker | 0.0627* | 0.0065 | 0.0377 | 0.0037 | 0.0855* | 0.0087 |
| | (0.0342) | | (0.0478) | | (0.0498) | |
| Office worker | 0.0520 | 0.0053 | 0.2153* | 0.0183 | −0.1168 | −0.0133 |
| | (0.0792) | | (0.1155) | | (0.1114) | |
| **Household characteristics** | | | | | | |
| Household size | −0.0151** | −0.0016 | −0.0226** | −0.0023 | −0.0073 | −0.0008 |
| | (0.00630 | | (0.0088) | | (0.0087) | |
| Number of children < 5 years | 0.4604*** | 0.0485 | 0.4563*** | 0.0454 | 0.4706*** | 0.0493 |
| | (0.0254) | | (0.0381) | | (0.0318) | |
| Hindu | −0.0022 | −0.0002 | −0.0558 | −0.0054 | 0.0656 | 0.0071 |
| | (0.1069) | | (0.1553) | | (0.1495) | |
| Muslim | 0.0220 | 0.0023 | −0.0437 | −0.0045 | 0.1127 | 0.0110 |
| | (0.1198) | | (0.1719) | | (0.1710) | |
| SC/ST/OBS | −0.0274 | −0.0029 | −0.0606 | −0.0059 | −0.0086 | −0.0009 |
| | (0.0396) | | (0.0558) | | (0.0564) | |
| Wealth quintile | | | | | | |
| 1 | −0.2804*** | −0.0330 | −0.2774* | −0.0309 | −0.2531 | −0.0292 |
| | (0.1093) | | (0.1498) | | (0.1638) | |
| 2 | −0.2562** | −0.0300 | −0.1965 | −0.0213 | −0.3076* | −0.0365 |
| | (0.1066) | | (0.1455) | | (0.1612) | |
| 3 | −0.1846* | −0.0211 | −0.1229 | −0.0129 | −0.2369 | −0.0275 |
| | (0.1029) | | (0.1390) | | (0.1574) | |
| 4 | −0.1638* | −0.0188 | −0.0035 | −0.0003 | −0.3317** | −0.0415 |
| | (0.0975) | | (0.1305) | | (0.1513) | |
| Main source of drinking water: piped | 0.0413 | 0.0042 | 0.0660 | 0.0063 | 0.0342 | 0.0035 |
| | (0.0667) | | (0.0954) | | (0.0937) | |
| Subcentre in village | 0.1306* | 0.0125 | 0.2453** | 0.0204 | 0.0353 | 0.0036 |
| | (0.0740) | | (0.1080) | | (0.1033) | |
| Private health clinic | 0.1397 | 0.0132 | 0.0908 | 0.0084 | 0.2063 | 0.0183 |
| | (0.1499) | | (0.2027) | | (0.2283) | |
| Child health clinic | −0.0390 | −0.0042 | −0.0051 | −0.0005 | −0.0863 | −0.0096 |
| | (0.0804) | | (0.1102) | | (0.1148) | |
| Govt. dispensary | 0.0058 | 0.0006 | −0.0070 | −0.0007 | 0.0309 | 0.0032 |
| | (0.1070) | | (0.1520) | | (0.1518) | |
| Govt. hospital | −0.2053 | −0.0254 | −0.5001*** | −0.0732 | 0.1078 | 0.0103 |
| | (0.1446) | | (0.1890) | | (0.2273) | |
| Private clinic | 0.0044 | 0.0005 | −0.0545 | −0.0057 | 0.0459 | 0.0046 |
| | (0.0998) | | (0.1443) | | (0.1351) | |
| Private hospital | 0.0601 | 0.0060 | 0.1453 | 0.0129 | −0.0105 | −0.0011 |
| | (0.0973) | | (0.1445) | | (0.1349) | |
| Mother able to keep money aside | −0.0322 | −0.0034 | −0.0593 | −0.0059 | 0.0003 | 0.0003 |
| | (0.0327) | | (0.0457) | | (0.0475) | |
| Mother needs permission to visit market | 0.0195 | 0.0021 | −0.0471 | −0.0046 | 0.0660 | 0.0071 |
| | (0.0628) | | (0.0910) | | (0.0851) | |
| Mother needs permission to visit friends | −0.0985 | −0.0098 | −0.0278 | −0.0027 | −0.1455 | −0.0140 |
| | (0.0678) | | (0.0955) | | (0.0940) | |
| Mother has say on health care | 0.0459 | 0.0048 | 0.0640 | 0.0063 | 0.0356 | 0.0037 |
| | (0.0326) | | (0.0457) | | (0.0469) | |
| **State** | | | | | | |
| Andhra Pradesh | 0.5210*** | 0.0372 | 0.5928*** | 0.0376 | 0.4742*** | 0.0349 |
| | (0.0947) | | (0.1455) | | (0.1260) | |
| Assam | −0.0149 | −0.0016 | −0.0624 | −0.0065 | 0.0107 | 0.0011 |
| | (0.0896) | | (0.1214) | | (0.1347) | |
| Bihar | 0.1273** | 0.0124 | 0.0700 | 0.0067 | 0.1823** | 0.0171 |
| | (0.0586) | | (0.0816) | | (0.0849) | |

*(Continued on next page)*

Table 7. Probit estimates of child survival. *(Continued)*

| | Full sample | Marginal effect | Males | Marginal effect | Females | Marginal effect |
|---|---|---|---|---|---|---|
| Gujarat | 0.3167*** | 0.0263 | 0.2053 | 0.0174 | 0.4515*** | 0.0336 |
| | (0.0973) | | (0.1352) | | (0.1381) | |
| Haryana | −0.0015 | −0.0002 | −0.0282 | −0.0029 | 0.0332 | 0.0034 |
| | (0.0902) | | (0.1233) | | (0.1335) | |
| Himachal Pradesh | 0.2402** | 0.0211 | 0.1363 | 0.0122 | 0.3842** | 0.0300 |
| | (0.1144) | | (0.1508) | | (0.1775) | |
| Karnataka | 0.6155*** | 0.0412 | 0.6260*** | 0.0389 | 0.6074*** | 0.0406 |
| | (0.0937) | | (0.1348) | | (0.1330) | |
| Kerala | 1.1332*** | 0.0515 | 1.0227*** | 0.0467 | 1.3384*** | 0.0531 |
| | (0.1846) | | (0.2151) | | (0.3388) | |
| Madhya Pradesh | 0.0715 | 0.0072 | 0.0609 | 0.0058 | 0.0858 | 0.0085 |
| | (0.0593) | | (0.0830) | | (0.0856) | |
| Maharashtra | 0.6062*** | 0.0406 | 0.6439*** | 0.0394 | 0.5676*** | 0.0388 |
| | (0.0986) | | (0.1407) | | (0.1403) | |
| Orissa | 0.1652** | 0.0155 | 0.1829* | 0.0160 | 0.1320 | 0.0126 |
| | (0.0715) | | (0.1002) | | (0.1032) | |
| Punjab | 0.2184* | 0.0195 | 0.3294* | 0.0254 | 0.1679 | 0.0155 |
| | (0.1302) | | (0.1922) | | (0.1815) | |
| Rajasthan | 0.1339** | 0.0130 | 0.1841** | 0.0163 | 0.0845 | 0.0084 |
| | (0.0600) | | (0.0851) | | (0.0857) | |
| Tamil Nadu | 0.7841*** | 0.0463 | 0.8291*** | 0.0443 | 0.7547*** | 0.0452 |
| | (0.1135) | | (0.1653) | | (0.1591) | |
| West Bengal | 0.5962*** | 0.0403 | 0.5174*** | 0.0348 | 0.7097*** | 0.0439 |
| | (0.1020) | | (0.1339) | | (0.1602) | |

*Significance at the 10% level; **significance at the 5% level; ***significance at the 1% level.



of survival. This survival probability increases to 2.7% in the case of infants whose mothers have higher than secondary level of education.

The fact that information available to the mother regarding health care and health facilities can have statistically significant effects on child mortality is supported by the finding that the probability of a child surviving past the first birthday is positively correlated to whether or not the mother has used ORS and has heard of ORS.[8] If the mother has used ORS, it increases the likelihood of survival by 1.6%. Similarly, the age of the mother at the time of birth has a statistically significant effect on child mortality. For example, we find that relative to children born to women aged 20–24 at the time of the birth of the child, the probability of child survival is higher and is statistically significant for children born to older mothers aged 25–29, 30–34 and 35, respectively.

The health input variables do not appear to have a particularly strong effect on survival probabilities. The only two statistically significant variables in the full sample are the presence of a sub-centre in the village and whether the child was delivered at home or in a government hospital. In particular, it is worth noting that while the presence of a sub-centre is significantly and positively correlated with survival probabilities, the child's survival probabilities are significantly correlated with home birth (relative to the child being born in a governmental hospital). These coefficient estimates should, however, be interpreted with some caution. Firstly, the fact that the probability of infant survival is significantly higher if the child is born at home rather than in a government hospital could be indicative of the general poor facilities and services in these hospitals. Secondly, it is also likely that more 'risky' births happen in hospitals so that the negative sign on hospital births may be indicative of a difficult birth. Thirdly, our dependent variable is defined as survival of an infant in the first year, and it is likely that poor delivery conditions have

Table 8. Selection-corrected OLS estimates of HAZ and WHZ.

| | HAZ | | | WHZ | | |
|---|---|---|---|---|---|---|
| | Full sample | Male | Female | Full sample | Male | Female |
| Constant | −0.7778*** | −0.7946*** | −0.6671*** | −0.1583 | −0.2407* | −0.1246 |
| | (0.1272) | (0.1732) | (0.1832) | (0.1001) | (0.1373) | (0.1435) |
| Male | 0.0491** | | | −0.0088 | | |
| | (0.0246) | | | (0.0194) | | |
| Birth-order | | | | | | |
| 2 | −0.0327 | −0.0130 | −0.0481 | −0.0236 | 0.0012 | −0.0551 |
| | (0.0349) | (0.0480) | (0.0508) | (0.0275) | (0.0380) | (0.0398) |
| 3 | −0.0381 | −0.0046 | −0.0916 | −0.0283 | 0.0238 | −0.0936** |
| | (0.0392) | (0.0534) | (0.0583) | (0.0308) | (0.0424) | (0.0456) |
| 4 | 0.0058 | −0.0234 | 0.0378 | −0.0359 | 0.0326 | −0.1203** |
| | (0.0457) | (0.0623) | (0.0671) | (0.0360) | (0.0494) | (0.0526) |
| 5 | −0.0955* | −0.1386* | −0.0689 | −0.0397 | 0.0287 | −0.1148* |
| | (0.0534) | (0.0734) | (0.0781) | (0.0421) | (0.0582) | (0.0612) |
| 6 | −0.0918* | 0.0074 | −0.2147*** | −0.0667* | −0.0129 | −0.1322** |
| | (0.0484) | (0.0659) | (0.0718) | (0.0381) | (0.0523) | (0.0562) |
| Twin | −0.5102*** | −0.4039*** | −0.5888*** | −0.0277 | −0.1612* | 0.0629 |
| | (0.0762) | (0.1096) | (0.1057) | (0.0600) | (0.0869) | (0.0828) |
| Child's age | −1.9576*** | −1.9942*** | −1.9218*** | −0.8922*** | −0.9718*** | −0.7930*** |
| | (0.0541) | (0.0743) | (0.0789) | (0.0426) | (0.0589) | (0.0618) |
| Age squared | 0.6362*** | 0.6890*** | 0.5806*** | 0.3288*** | 0.3768*** | 0.2688*** |
| | (0.0261) | (0.0358) | (0.0381) | (0.0206) | (0.0284) | (0.0298) |
| **Maternal characteristics** | | | | | | |
| Use ORS | 0.0134 | 0.0267 | −0.0005 | −0.0304 | −0.0526 | 0.0049 |
| | (0.0315) | (0.0436) | (0.0455) | (0.0248) | (0.0346) | (0.0356) |
| Heard of ORS | 0.0609* | 0.0732 | 0.0466 | −0.0391 | −0.0648* | −0.0010 |
| | (0.0330) | (0.0449) | (0.0485) | (0.0260) | (0.0356) | (0.0380) |
| Literate, but less than middle school completion | 0.1230*** | 0.1599*** | 0.0738 | 0.0346 | 0.0382 | 0.0346 |
| | (0.0370) | (0.0507) | (0.0539) | (0.0291) | (0.0402) | (0.0422) |
| Middle school complete | 0.1925*** | 0.2219*** | 0.1299* | 0.0712* | 0.0599 | 0.0843 |
| | (0.0517) | (0.0691) | (0.0778) | (0.0407) | (0.0548) | (0.0609) |

*(Continued on next page)*

Table 8. Selection-corrected OLS estimates of HAZ and WHZ. *(Continued)*

| | HAZ | | | WHZ | | |
|---|---|---|---|---|---|---|
| | Full sample | Male | Female | Full sample | Male | Female |
| High school complete and higher | 0.2846*** | 0.3495*** | 0.1974** | 0.1476*** | 0.1204** | 0.1888*** |
| | (0.0559) | (0.0759) | (0.0824) | (0.0440) | (0.0602) | (0.0645) |
| Not working | 0.0374 | 0.0431 | 0.0286 | 0.0609*** | 0.1079*** | 0.0136 |
| | (0.0298) | (0.0409) | (0.0432) | (0.0234) | (0.0325) | (0.0339) |
| **Paternal characteristics** | | | | | | |
| Literate, but less than middle school completion | 0.0554 | 0.0848* | 0.0249 | 0.0105 | −0.0242 | 0.0519 |
| | (0.0340) | (0.0468) | (0.0497) | (0.0268) | (0.0371) | (0.0389) |
| Middle school complete | 0.1422*** | 0.1818*** | 0.1044* | 0.0733** | 0.0956** | 0.0518 |
| | (0.0415) | (0.0575) | (0.0597) | (0.0326) | (0.0456) | (0.0468) |
| High school complete and higher | 0.1466*** | 0.1810*** | 0.1131* | 0.0757** | 0.0237 | 0.1374*** |
| | (0.0410) | (0.0567) | (0.0590) | (0.0322) | (0.0449) | (0.0462) |
| Occupation | | | | | | |
| Manual worker | −0.0288 | 0.0064 | −0.0724* | −0.0052 | −0.0239 | 0.0175 |
| | (0.0275) | (0.0375) | (0.0402) | (0.0216) | (0.0297) | (0.0315) |
| Office worker | 0.0582 | 0.0725 | 0.0365 | −0.0692 | −0.0894 | −0.0402 |
| | (0.0538) | (0.0722) | (0.0807) | (0.0423) | (0.0573) | (0.0632) |
| **Household characteristics** | | | | | | |
| Household size | −0.0075* | −0.0091 | −0.0045 | 0.0008 | 0.0020 | −0.0024 |
| | (0.0041) | (0.0057) | (0.0058) | (0.0032) | (0.0045) | (0.0046) |
| Number of children < 5 years | 0.0084 | 0.0260 | −0.0205 | 0.0066 | −0.0011 | 0.0268 |
| | (0.0161) | (0.0220) | (0.0231) | (0.0127) | (0.0174) | (0.0181) |
| Hindu | −0.1014 | −0.2081** | 0.0339 | −0.0708 | −0.0143 | −0.1300 |
| | (0.0704) | (0.0948) | (0.1048) | (0.0554) | (0.0752) | (0.0821) |
| Muslim | −0.1817** | −0.2934*** | −0.0338 | −0.1481** | −0.1035 | −0.1913** |
| | (0.0803) | (0.1081) | (0.1195) | (0.0632) | (0.0857) | (0.0936) |
| SC/ST/OBS | −0.1704*** | −0.2130*** | −0.1199*** | −0.0695*** | −0.0673** | −0.0700** |
| | (0.0298) | (0.0406) | (0.0437) | (0.0234) | (0.0322) | (0.0343) |
| Wealth quintile | | | | | | |
| 1 | −0.5686*** | −0.4845*** | −0.6701*** | −0.2690*** | −0.3151*** | −0.2172*** |
| | (0.0663) | (0.0905) | (0.0971) | (0.0521) | (0.0717) | (0.0760) |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | −0.4785*** | −0.4168*** | −0.5559*** | −0.2333*** | −0.2533*** | −0.2126*** |
| | (0.0628) | (0.0855) | (0.0923) | (0.0494) | (0.0678) | (0.0723) |
| 3 | −0.3996*** | −0.3699*** | −0.4472*** | −0.1669*** | −0.1442** | −0.1969*** |
| | (0.0589) | (0.0804) | (0.0864) | (0.0463) | (0.0638) | (0.0676) |
| 4 | −0.2438*** | −0.2013*** | −0.3060*** | −0.1126** | −0.0970 | −0.1351** |
| | (0.0555) | (0.0748) | (0.0825) | (0.0436) | (0.0593) | (0.0646) |
| Mother able to keep money aside | 0.0322 | 0.0763** | −0.0192 | −0.0059 | 0.0089 | −0.0233 |
| | (0.0264) | (0.0361) | (0.0386) | (0.0208) | (0.0286) | (0.0302) |
| Mother needs permission to visit market | 0.0433 | 0.0661 | 0.0080 | −0.0681* | −0.0670 | −0.0752 |
| | (0.0473) | (0.0646) | (0.0691 | (0.0372) | (0.0512) | (0.0541) |
| Mother needs permission to visit friends | −0.0936* | −0.0823 | −0.0955 | 0.0470 | 0.0720 | 0.0201 |
| | (0.0501) | (0.0682) | (0.0736) | (0.0394) | (0.0541) | (0.0576) |
| Mother has say on health care | 0.0426 | 0.0128 | 0.0731* | −0.0279 | −0.0359 | −0.0146 |
| | (0.0261) | (0.0356) | (0.0382) | (0.0206) | (0.0282) | (0.0299) |
| **State** | | | | | | |
| Andhra Pradesh | 0.3639*** | 0.3386*** | 0.4000*** | 0.0462 | 0.0713 | 0.0194 |
| | (0.0702) | (0.0969) | (0.1020) | (0.0553) | (0.0768) | (0.0799) |
| Assam | 0.1692** | 0.0434 | 0.3243*** | 0.7511*** | 0.7103*** | 0.8083*** |
| | (0.0778) | (0.1052) | (0.1156) | (0.0613) | (0.0834) | (0.0906) |
| Bihar | 0.1251** | 0.1122 | 0.1419* | −0.0963** | −0.1093** | −0.0770 |
| | (0.0504) | (0.0695) | (0.0733) | (0.0397) | (0.0551) | (0.0574) |
| Gujarat | 0.1450** | 0.1453 | 0.1414 | −0.1376** | −0.1292 | −0.1467 |
| | (0.0731) | (0.1009) | (0.1062) | (0.0576) | (0.0800) | (0.0831) |
| Haryana | −0.1842*** | −0.1211 | −0.2574** | 0.4013*** | 0.3279*** | 0.4867*** |
| | (0.0707) | (0.0956) | (0.1051) | (0.0557) | (0.0758) | (0.0823) |
| Himachal Pradesh | 0.0025 | −0.1680 | 0.1901 | −0.1851*** | −0.1731** | −0.2001** |
| | (0.0757) | (0.1029) | (0.1116) | (0.0596) | (0.0816) | (0.0874) |
| Karnataka | 0.5951*** | 0.6105*** | 0.5812*** | −0.3365*** | −0.3328*** | −0.3415*** |
| | (0.0688) | (0.0954) | (0.0994) | (0.0542) | (0.0756) | (0.0778) |
| Kerala | 0.6998*** | 0.5903*** | 0.8276*** | −0.1275 | −0.1798*** | −0.0650 |
| | (0.0882) | (0.1218) | (0.1279) | (0.0695) | (0.0966) | (0.1002) |
| Madhya Pradesh | 0.1462*** | 0.1691** | 0.1263 | −0.2615*** | −0.2884*** | −0.2343*** |
| | (0.0529) | (0.0727) | (0.0769) | (0.0416) | (0.0577) | (0.0602) |

*(Continued on next page)*

Table 8. Selection-corrected OLS estimates of HAZ and WHZ. *(Continued)*

| | HAZ | | | WHZ | | |
|---|---|---|---|---|---|---|
| | Full sample | Male | Female | Full sample | Male | Female |
| Maharashtra | 0.3363*** | 0.2402** | 0.4449*** | −0.4797*** | −0.4749*** | −0.4863*** |
| | (0.0708) | (0.0961) | (0.1048) | (0.0558) | (0.0762) | (0.0821) |
| Orissa | 0.5190*** | 0.4851*** | 0.5663*** | −0.4362*** | −0.4750*** | −0.3913*** |
| | (0.0605) | (0.0824) | (0.0889) | (0.0476) | (0.0653) | (0.0696) |
| Punjab | 0.0740 | 0.0409 | 0.1176 | 0.2420*** | 0.2431** | 0.2499** |
| | (0.0900) | (0.1226) | (0.1325) | (0.0708) | (0.0972) | (0.1038) |
| Rajasthan | 0.0299 | 0.0322 | 0.0256 | −0.0208 | −0.0655 | 0.0295 |
| | (0.0504) | (0.0689) | (0.0740) | (0.0397) | (0.0546) | (0.0580) |
| Tamil nadu | 0.7666*** | 0.7020*** | 0.8426*** | −0.2762*** | −0.3433*** | −0.2055** |
| | (0.0757) | (0.1037) | (0.1109) | (0.0596) | (0.0822) | (0.0868) |
| West Bengal | 0.2806*** | 0.3410*** | 0.2295** | −0.1306** | −0.1638** | −0.0980 |
| | (0.0701) | (0.0957) | (0.1032) | (0.0552) | (0.0758) | (0.0808) |
| $\lambda$ | 0.1344 | −0.0127 | 0.1139 | −0.0010 | 0.0511 | 0.0946 |
| | (0.1231) | (0.1692) | (0.1719) | (0.0969) | (0.1341) | (0.1346) |

Note: Superscripts ***, ** and * denote significance at 1%, 5% and 10% levels, respectively.The regressions also included controls for a set of state of residence dummies.

their effect in the first week of life.[9] Finally, several studies (summarised in Strauss and Thomas 1998) have argued that local health infrastructure could be endogenous in the child health regressions. This could happen because (1) individuals might choose their residence on the basis of the availability of public health services (see Rosenzweig and Wolpin 1988) and (2) local infrastructure itself might be placed selectively by public policy, perhaps in response to local health conditions (see Rosenzweig and Wolpin 1986). While selective migration in response to local infrastructure variables is unlikely to be particularly common in a developing country like India, selective placement of health services is, however, potentially a much more important issue. Although we acknowledge this potential endogeneity of the local infrastructure variables, we ignore this issue in our estimation because of a lack of adequate instruments.

With regard to household-specific variables, household wealth is statistically significant and positively correlated with improved infant survival probabilities. In particular, we observe that relative to children from households in the highest wealth quintile, being born in lower wealth quintiles significantly reduces survival probabilities. For example, a child born in the lowest wealth quintile has a 3.3% lower probability of surviving relative to a child from the highest wealth quintile.

Finally, and not surprisingly, there are significant regional differences in child survival rates. In the full sample, relative to a child in the northern state of Uttar Pradesh, the probability of an infant surviving to their first birthday is statistically significant and positively correlated for children from all the states in our sample with the exception of Assam, Haryana and Madhya Pradesh, where it is insignificant. In particular, it is worth noting that in keeping with *a priori* expectations, survival probabilities of infants are significantly higher in the south-eastern states of Kerala, Karnataka, Andhra Pradesh, Tamil Nadu and West Bengal. For example, a child from the southern state of Kerala has a 5% higher probability of survival relative to a child from Uttar Pradesh, with a girl child also facing similar higher probabilities. On the other hand, the survival probabilities of children from the states of Gujarat, Punjab and Bihar, albeit positive relative to Uttar Pradesh, have marginal effects of much smaller sizes relative to the southern states. As the next section will show, the gender differences in survival probabilities are particularly noteworthy across the different states.

### 4.2. *Anthropometric measures*

We now turn to the Heckman two-step estimates of HAZ and WHZ, presented in Table 8, columns 1 and 4 respectively for the full sample.

The first point to note is that the coefficient for the inverse Mill's ratio ($\widehat{\lambda}$) is not statistically significant in either the HAZ regressions or the WHZ regressions. This implies that in studying child nutrition, mortality selection is not an issue we should be concerned about. Hence, for our sample, the empirical evidence refutes Udry's (1997) sample truncation hypothesis and Rose's (1999) differential mortality selection hypothesis.

Is there any evidence of nutritional disadvantage for female children? In the OLS estimates for HAZ, we note that in the full sample the gender dummy is positive and statistically significant, indicating that other things equal, boys are significantly more likely to be taller than girls. The child's gender is, however, insignificant in the case of WHZ.

The age of the child is associated with a non-linear effect on the nutrition status of the child. However, within the relevant age range, the negative effect dominates, and an increase in the age of the child is associated with an improvement in *z*-scores, both HAZ and WHZ.

With regard to the birth-order effects, we see that both HAZ and WHZ are significantly lower for higher birth-order children (later-born children), specifically birth-order fifth and sixth in the case of HAZ and birth-order sixth and above in the case of WHZ. However, it is worth emphasising that birth-order is only weakly significant at the 10% level. In any case, these results indicate that later-born children have poorer nutritional outcomes, suggesting some competition for household resources.

Both the mother's and the father's educational attainment have statistically significant effects on HAZ. The educational attainment of the parents also has a statistically significant effect on WHZ, but in the case of mothers, only the highest educational category is statistically significant.

Turning to other household characteristics, both HAZ and WHZ are unsurprisingly lower for children belonging to backward castes (scheduled castes, scheduled tribes and other backward castes) relative to upper castes. Having a non-working mother is associated with an increase in WHZ but is insignificant in the case of HAZ. Father's occupation, on the other hand, is insignificant in influencing child nutritional outcomes.

The relative bargaining power of the mother (or the mother's autonomy variables) does not have a particularly strong effect on the nutrition status of the children. We see that HAZ is statistically significant and negatively correlated to the variable 'mother needs permission to visit family'; WHZ is significantly and negatively correlated to the mother requiring permission to visit the market. However, one can, of course, argue that it is not surprising that the mother's relative bargaining power does not have a particularly strong direct effect on the nutrition status of the children. Maitra (2004) used the same data-set to show that although the mother's relative bargaining power did not have a direct effect on the health of children (in that paper measured using child mortality), there was a strong indirect effect through the use of health inputs.

Finally, there are regional disparities in child nutritional outcomes. Relative to the state of Uttar Pradesh, HAZs are significantly higher for children from all the states in our sample with the exception of the states of Haryana, Himachal Pradesh and Punjab, where there is no statistically significant effect. The pattern is very different in the case of WHZ, where we observe that relative to Uttar Pradesh, WHZs are significantly poorer for children from the states of Bihar, Gujarat, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra and Orissa. On the other hand, the WHZs are significantly better for children from the northern states of Haryana and Punjab.

### 4.3. *Gender-differentiated effects of child survival and nutrition estimates*

In order to examine whether the explanatory variables have differential effects on the mortality and nutrition status of boys and girls, we present gender-specific estimates for the sample of girls and boys. As previously mentioned, our analysis finds no evidence of mortality selection in the gender-differentiated sample either. However, even with regard to the two nutrition measures, there are some interesting differences in terms of how (some of) the explanatory variables affect the WHZ and HAZ of boys and girls.

In columns 3 and 4 of Table 7, we present the coefficients (robust standard errors in parentheses) and marginal effects for the probit estimation on the probability of child survival for boys, while in Columns 5–6, we present the corresponding results for girls.

Several differences can be observed between the two samples on survival probabilities of infants. Our analysis shows that regional effects are significant for both samples. In line with the findings for the full sample, we observe that relative to the base category of Uttar Pradesh, survival probabilities are significantly higher in the southern states of Karnataka, Andhra Pradesh, Kerala, Tamil Nadu, Maharashtra and in the western state of West Bengal for both boys and girls. On the other hand, while boys from the states of Punjab, Rajasthan and Orissa have statistically significant and positive survival probabilities compared with boys from the state of Uttar Pradesh, the differences are not statistically significant in the case of girls. Interestingly, while girls from the states of Bihar, Gujarat and Himachal Pradesh have significantly higher survival probabilities relative to girls from Uttar Pradesh, there are no statistically significant effects for boys from these states. These statewide differences between boys and girls, in particular, the north–south divide, are consistent with the findings of previous studies from India (Dyson and Moore 1983, Kishor 1993, Murthi *et al*. 1995, Pande 2003).

The influence on survival probabilities of child-specific variables such as birth-order, birthweight, place of delivery, mother's age and twin birth has similar effects on boys and girls. However, it is worth noting that the size of the coefficients is larger in the case of girls relative to boys, indicating that later-born girls are disadvantaged greater than later-born boys. Turning to the role of parental education, we observe that for girls, mother's education, in particular, having a mother with primary school and college education is statistically significant and positively correlated with survival probabilities. These variables are insignificant for boys, while in contrast we note that having a secondary-educated mother is significantly and positively related to survival probabilities for the full sample. On the other hand, boys with a primary-educated father or college-educated father have higher survival probabilities, whereas for girls, only the highest level of father's education is statistically significant. Similarly, we observe that for boys, having a mother who does not work is positively and significantly correlated with survival probabilities. This variable, however, is not significant in the case of girls.

Variables relating to sibling and household demographic characteristics are statistically significant and also affect both girls and boys in a similar manner. Being part of a twin and an increase in the number of children under five years of age is significantly and negatively correlated with survival probabilities for both girls and boys.

In Table 8, we present gender-differentiated estimation results for WHZ and HAZ, where we observe interesting differences in the way in which the explanatory variables affect boys and girls differently. For example, the birth-order variables are not statistically significant in the WHZ estimates for boys, whereas for girls, we see that relative to the first-born girl, WHZ is significantly lower for girls born third, fourth, fifth, sixth or higher in the birth-order. With regard to the HAZ on the other hand, we see that for a boy, being fifth in the birth-order is statistically significant and negatively correlated with HAZ, while for girls, we observe that only the sixth birth-order is significantly correlated with HAZ.

In terms of regional influences, relative to Uttar Pradesh (base category), WHZs are significantly lower for boys from Bihar, Gujarat, Madhya Pradesh, Maharashtra, Kerala, Karnataka, Tamil Nadu and West Bengal, whereas they are better for boys from Haryana, Punjab and Assam. For girls, we see similar regional effects. However, in terms of long-term nutrition (HAZ), we observe that relative to a girl from Uttar Pradesh, girls from the southern states of Andhra Pradesh, Maharashtra, Kerala, Karnataka, Tamil Nadu and the Eastern states of Orissa, Assam and West Bengal fare better in HAZs. On the other hand, in Haryana where gender discrimination against girls is more profound, we find lower HAZ for girls.

### 4.4. *Comparing OLS with ordered probit results*

Comparing the ordered probit results with the OLS estimates, we observe that the estimation results in general are similar, with the signs of the explanatory variables and the size of the coefficients being similar in the two models. For example, like the OLS estimates, the ordered probit results also show that boys are significantly more likely than girls to be in the highest HAZ category, with no significant gender effects observed with regard to the WHZ estimates. Similarly, having a mother who is secondary educated and above is positively correlated with the child being in the highest HAZ and WHZ category, in the full sample as well as in the gender-differentiated samples. The regional variations are also similar to those found in the OLS estimates.

## 5. Concluding comments and policy implications

This paper has examined if there are gender differences in infant mortality and whether they manifest into gender-differentiated child nutrition outcomes for children, using a sample selection model. We do not find any evidence of sample truncation, and our results do not support the widely held view of gender discrimination in infant survival outcomes. These results should be treated with some caution, however, since our analysis focuses only on children who are born alive, and we are unable to control for the presence of selective foeticide and infanticide of girls whose births have not been registered. There is likely to be some underestimation of deaths.

While being male has no significant effect on WHZ, a male child has a significantly better HAZ relative to a female child. One implication of this is that while there are no gender differences in short-term nutrition, the long-term nutrition of boys is significantly better than that of girls. In addition, we find that long-term nutrition is poorer for children of higher birth-order (later-born children), and the effect is monotonically increasing. Since HAZ is a stock measure of nutritional trends, the big picture for Indian children is a cause for concern.

A number of policy implications arise from our findings. First, in keeping with the findings from previous studies, large statewide differences are observed in both infant survival probabilities and child nutritional measures. These differences appear not to be related to economic factors, as children from the southern states have better survival probabilities and HAZ outcomes compared with children from Uttar Pradesh, whereas we do not see significantly better outcomes for children from the more affluent state of Punjab. We hypothesise that the regional differences in child survival outcomes and child nutritional status are linked to the role of women and maternal autonomy. Second, the improved survival probabilities and better nutritional outcomes of children with better-educated mothers suggest that mother's education is an avenue that policy-makers could potentially use to address inequities in child health outcomes. The high proportion of mothers in the sample with no education is clearly a policy concern. Third, the lower survival probability of infants and the poorer nutritional status of children from the lower wealth quintiles are indicative of the adverse affects of poverty on infant survival and nutritional outcomes.

From our descriptive statistics, we have seen that the children in our sample are over-represented in the poorest wealth quintile and are underrepresented in the richest wealth quintile. This suggests that young rural children are growing in poverty, and as poor child health outcomes are linked to a lack of access to medical and food resources, from a policy perspective, it is imperative that efforts are made to improve the rural medical infrastructure. The lack of availability of medical facilities can have a detrimental effect on households seeking medical care for their children. In our sample, only 2% of the children live in villages with a primary health centre and less than 5% of the children have access to any type of medical facility. From a health promotion perspective, our results indicate that simple measures such as provision of safe drinking water and improving maternal knowledge of ORS will improve child survival and nutrition outcomes.

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## Notes

1. Additionally, there is a geographical dimension to this problem: several studied have identified a north–south divide with an observed relatively higher female mortality in the northern–western states of Uttar Pradesh, Bihar, Punjab and Haryana relative to the south-eastern states of Andhra Pradesh, Kerala, Karnataka and Tamil Nadu.
2. We do not include urban children since there is no data on community characteristics for urban areas. Moreover, since over 70% of the Indian population lives in rural areas, our sample is fairly representative.
3. There is no child in our sample who is over 54 months of age.
4. The average female HAZ is −2.0202, and the average male HAZ is −1.9607. The difference is statistically significant ($t = -1.9298$; $p = 0.0537$). The gender difference in WHZ is, however, not statistically significant. The average female WHZ and the average male WHZ are −0.8856 ($t = 0.3055$; $p = 0.7600$).
5. We exclude from the final estimating sample those children who are not alive at the time of the survey but died after their first birthday, as anthropometric measures are not available for these children.
6. Theoretically, children having a lower birthweight have a higher probability of not surviving to their first birthday, and this is independent of parental actions after birth. However, it is worth noting that the child's birthweight is imprecisely measured in our data set – it is based on the mother's recollection and could be subject to significant measurement errors.
7. The effect of birth-order on the probability of survival is ambiguous. On the one hand, higher birth-order (later born) children are born to older mothers and may therefore have a higher probability of survival since the mother is likely to be more experienced and may be in a better position to deal with unexpected health problems. On the other hand, higher parity children and girls in particular may be neglected due to resource constraints, especially in large households where a strong son preference is prevalent.
8. It is important to note that including these two variables relating to ORS could lead to a potential endogeneity problem, as these two variables (and for that matter, all of the behavioural variables, such as choosing hospital delivery) could be correlated with the unobserved determinants of child survival (for example, mothers who use ORS might not be a random subset of mothers). We acknowledge that there exists this potential endogeneity problem, but given the lack of adequate instruments, we do not correct for this potential problem. No causal interpretation should therefore be drawn from these estimates.
9. We are grateful to an anonymous referee for pointing this out.

## References

Bardhan, P.K., 1988. Sex disparity in child survival in Rural India. *In*: T.N. Srinivasan and P.K. Bardhan, eds. *Rural poverty in South Asia*. New York: Columbia University Press, 473–480.

Basu, A.M., 1989. Is discrimination in food really necessary for explaining sex differentials in childhood mortality. *Population studies*, 43, 193–210.

Basu, A.M., 1993. How pervasive are sex differentials in childhood nutritional levels in South Asia? *Social biology*, 40 (1–2), 25–37.

Behrman, J.R., 1988. Intrahousehold allocation of nutrients in rural India: are boys favored? Do parents exhibit inequality aversion? *Oxford economic papers*, 40, 32–54.

Behrman, J.R., 1998. Intra-household allocation of resources: is there a Gender bias? *In*: *Too young to die: genes or gender?* New York: United Nations, 223–242.

Bloom, S., Wypij, D., and Das Gupta, M., 2001. Dimensions of women's autonomy and the influence on maternal health care utilization in a North Indian City. *Demography*, 38 (1), 67–78.

Census of India, 2001. Provisional population totals, Chapter 7, Series 1, Paper 1 of 2001.

Das Gupta, M., 1987. Selective discrimination against female children in rural Punjab. *Population and development review*, 13 (1), 77–100.
Dyson, T. and Moore, M., 1983. On Kinship structure, female autonomy, and demographic behavior in India. *Population and development review*, 9 (1), 35–60.
Filmer, D. and Pritchett, L., 2001. Estimating wealth effects without expenditure data – or tears: an application to educational enrollments in States of India. *Demography*, 38, 115–132.
Glewwe, P., 2000. Why does mother's schooling raise child health in developing countries? Evidence from Morocco. *Journal of human resources*, XXXIV, 124–159.
Glick, P. and Sahn, D., 1995. *Maternal labor supply and child nutrition in West Africa (*Mimeo*)*. Ithaca, NY: Cornell University.
Harriss, B., 1999. The intrafamily distribution of hunger in South Asia. *In*: J. Dreze, A. Sen, and A. Hussien, eds. *The political economy of hunger: selected essays*. Oxford: Clarendon Press, 224–297.
Kassouf, A.L. and Senauer, B., 1996. Direct and indirect effects of parental education on malnutrition among children in Brazil: a full income approach. *Economic development and cultural change*, 44 (4), 817–838.
Kishor, S., 1993. May God give sons to all': gender and child mortality in India. *American sociological review*, 58, 247–265.
Leslie, J., 1988. Women's work and child nutrition in the Third World. *World development*, 16 (11), 1341–1362.
Maitra, P., 2004. Parental bargaining, health inputs and child mortality in India. *Journal of health economics*, 23, 259–291.
Mishra, V., Lahiri, S., and Luther, N.Y., 1999. Child nutrition in India. *In*: *National Family Health Survey subject reports No. 14*. Mumbai, India: International Institute for Population Sciences and Honolulu: East–West Center.
Murthi, M., Guio, A., and Dreze, J., 1995. Mortality, fertility and gender bias in India: a district-level analysis. *Population and development review*, 21 (4), 745–782.
National Family Health Survey, 1998–1999. *International Institute for Population Sciences (IIPS)*. Mumbai: Macro International.
Pande, R.P., 2003. Selective gender differences in childhood nutrition and immunization in Rural India: the role of siblings. *Demography*, 40 (3), 395–418.
Pelletier, D.L., 1998. The potentiating effects of malnutrition on child mortality: epidemiologic evidence and policy implications. *Nutrition review*, 52 (12), 409–415.
Rose, E., 1999. Consumption smoothing and excess female mortality in Rural India. *The review of economics and statistics*, 81 (1), 41–49.
Rosenzweig, M.R. and Wolpin, K.I., 1986. Evaluating the effects of optimally distributed public health programs: child health and family planning interventions. *American economic review*, 76 (3), 470–482.
Rosenzweig, M.R. and Wolpin, K.I., 1988. Migration selectivity and the effects of public programs. *Journal of public economics*, 37 (3), 265–289.
Sahn, D.E. and Alderman, H., 1997. On the determinants of nutrition in Mozambique: the importance of age-specific effects. *World development*, 25 (4), 577–588.
Sen, A.K., 1990. More than 100 Million women are missing. *The New York review of books*, 37 (20).
Sen, A.K. and Sengupta, S., 1983. Malnutrition of rural Indian children and the sex bias. *Economic and political weekly*, 18, 855–863.
Strauss, J., 1990. Household communities and preschool child nutrition outcomes: evidence from cote d'Ivoire. *Economic development and cultural change*, 38 (2), 231–261.
Strauss, J. and Thomas, D., 1995. Human resources: empirical modelling of household and family decisions. *In*: T.N. Srinivasan and J.R. Behrman, eds. *Handbook of development economics, Vol 3A*. Amsterdam: North Holland Press.
Strauss, J. and Thomas, D., 1998. Health, nutrition and economic development. *Journal of economic literature*, 36 (2), 766–817.
Sudha, S. and Rajan, S.I., 1999. Female demographic disadvantage in India 1981–1991: sex selective abortions and female infanticide. *Development and change*, 30 (3), 585–618.
Udry, C., 1997. Recent advances in empirical microeconomic research in poor countries: an annotated bibliography. *Journal of economic education*, 28 (1), 58–75.
Waterlow, J.C., *et al.*, 1997. The presentation and use of height and weight data for comparing the nutritional status of groups of children under the age of 10 years. *Bulletin of the World Health Organisation*, 55, 489–498.