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A Decomposition Analysis of the Change in Nutritional Outcomes of Girls between 1992-3 and 2005-6 in Rural India

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ABSTRACT

Not only is the prevalence of child undernutrition high, improvements have been slow relative to what might be expected given India’s remarkable progress in improving the rates of economic growth. This paper examines how nutritional outcomes have unfolded over time for young girls in rural India and seeks to answer to what extent can the improvement over time be attributed to (a) changes in distribution of covariates overtime and (b) differences in returns to covariates over time using counterfactual-based decomposition techniques at the mean (Oaxaca-Blinder (OB)) and across the percentiles (Machado-Mata (MM). The results suggest a trend of declining total change as one moves from lower to higher percentiles of the anthropometric distribution with significantly larger improvements for the relatively undernourished girls. The contributions of the covariate and coefficient effects differ across the distribution depending on the anthropometric outcome we consider. For the relatively undernourished girls, however, both the components are important.

Keywords: child nutrition, anthropometric outcome, quantile regression, decomposition

1. INTRODUCTION

Very little of India’s remarkable progress, as apparent in its increasing rates of economic growth, has translated into improving its anthropometric performance in lowering the rates of

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child undernutrition.[2] India continues to be home to more than a third of the world's stunted children (Haddad *et al*., 2015). Estimates from the recent nationwide Rapid Survey on Children (RSOC) classify about 39 percent of Indian children under five years of age as stunted and 30 percent as being underweight (RSOC, 2015).

Equally well documented is the preference for a male child amongst Indian parents. Both the sex-ratio and mortality rates for the under-five children are skewed in favor of boys: 91.9 girls for every 100 boys (Census of India, 2013) and 107.5 girl-child deaths for every 100 boy-child deaths (UN Report, 2015). Studies find evidence of girls being less likely to be fully vaccinated and getting immunization against diseases relative to boys which gets reflected in excessive female child mortality (Oster, 2009; Borooah, 2004). Discrimination is also seen among infants with girls being breastfed for shorter duration with long intervals in between, and over a short period than boys (Das Gupta, 1987).

Against this backdrop, this paper attempts to document how nutritional outcomes have unfolded over time for girls in India. It is argued that undernourished girls are more likely to become undernourished mothers and have children born with low birth weights (UNICEF, 2013). Also, given the higher prevalence of undernutrition in rural than in urban areas (Arnold *et al*., 2009), the analysis is restricted to young girls in rural India. As detailed below, this study attempts to identify what factors are associated with undernutrition of girls in a given cross-section, and then go on to use decomposition techniques to try and identify which of the socio-economic characteristics seem most associated with the observed change in outcomes between 1992/93 and 2005/06.

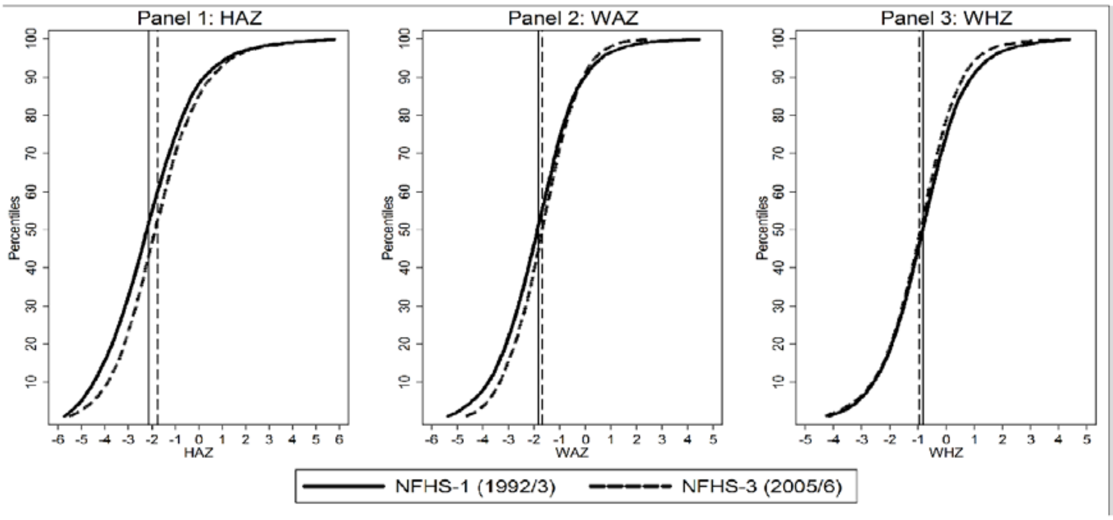
Table 1: Prevalence of undernutrition among rural girls, by NFHS round

	Stunting (%)	**Underweight (%)**	**Wasting (%)**
NFHS-1 (1992/93)	55	46	18
NFHS-3 (2005/06)	46	40	19
Change (in percentage points)[a]	9***	6***	-1

[2] The three most commonly used anthropometric indices (expressed in terms of z-scores) to assess child nutritional status are height-for-age z-score (HAZ), weight-for-age z-score (WAZ) and weight-for-height z-score (WHZ) (Waterlow *et al*., 1977). The z-scores employed in this analysis are calculated using the child growth standard developed by World Health Organization (WHO) Multicentre Growth Reference Study (2006) which uses a sample of approximately 8500 children under five years (healthy breasted infants and young children) from six countries from different cultural and ethnic backgrounds. Stunting (based on HAZ), underweight (based on WAZ) and wasting (based on WHZ), are each defined as their respective z-score being less than -2 standard deviations (SD) units.

Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)
Notes: a- Change is calculated as [% undernourished in 1992/93 - % undernourished in 2005/06]. The data refer to young girls under four years of age; ***, ** and * indicate significance at 1, 5, and 10 percent, respectively.

Table 1 provides estimates of prevalence of stunting, underweight and wasting among rural girls below the age of four for the first (1992/93) and third (2005/06) rounds of the National Family and Health Survey (NFHS).[3] We see that over the thirteen year period, stunting and underweight prevalence fell by 9 and 6 percentage points respectively, and in 2005/06 their levels are still high at 46 and 40 percent respectively.[4] The change in the prevalence of wasting is insignificant, and in 2005/06 its level is at 19 percent.[5] Since weight-for-height z-score (WHZ) can be expressed as the ratio of weight-for-age z-score (WAZ) and height-for-age z-score (HAZ), the insignificant change is a result of similar proportionate declines in the prevalence of being underweight and the prevalence of stunting. However, a comparison based on proportions alone does not reveal whether a similar change has occurred at different percentiles of the anthropometric distributions. Panels 1, 2 and 3 of Figure 1 plots the distribution of the HAZ, WAZ and WHZ outcomes, respectively.



Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)
Notes: The data refer to young girls under four years of age.

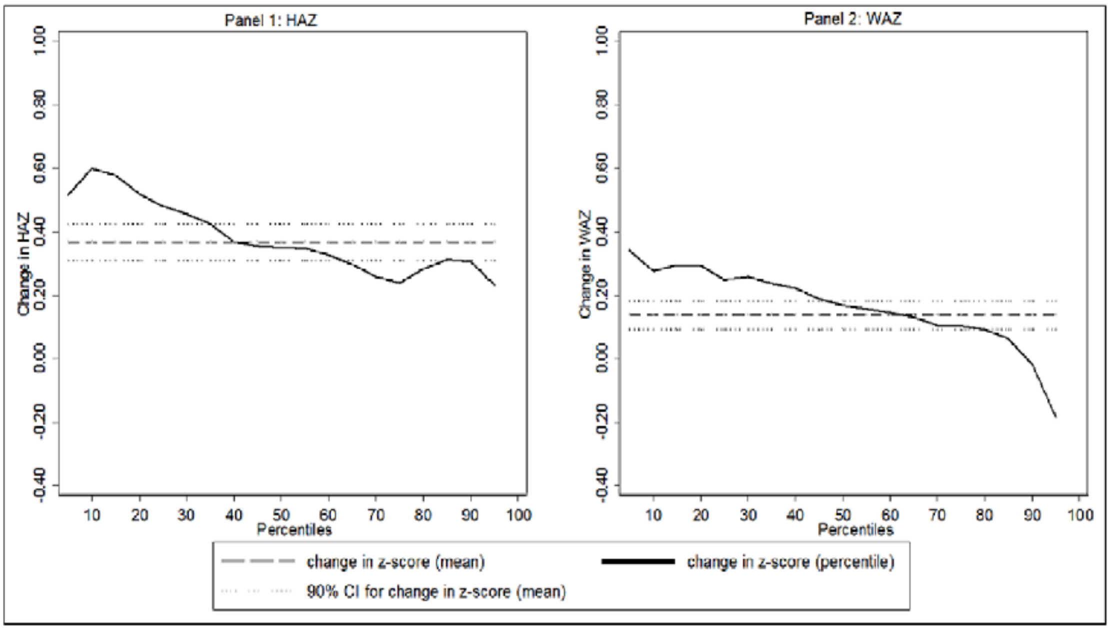
Figure 1: Distribution of anthropometric outcomes of rural girls

[3] To make the datasets comparable across the two rounds, we restrict our analysis to girls below age four. More on this in Section 2.3.

[4] The null hypothesis that the proportion of girls stunted (or underweight) in 1992/93 is equal to the proportion stunted (or underweight) in 2005/06 is rejected using the test for differences in proportions.

[5] The null hypothesis that the proportion of girls wasted in 1992/93 is equal to the proportion wasted in 2005/06 cannot be rejected using the test for differences in proportions.

Panel 1 shows that the HAZ curve for 2005/06 lies everywhere to the right of that for 1992/93 except beyond the 90th percentile where the plots overlap. This implies that the HAZ measure has improved over time for all percentiles up to the 90th.[6] Moreover, we see significantly greater improvements for stunted (HAZ < (-2)) and severely stunted (HAZ < (-3)) girls as compared to healthy (HAZ between (-2) and (+6)) girls. In Panel 2, which does the same for WAZ, most of the improvement is below the 70th percentile.[7] We see in Panel 3 that there is no worsening of WHZ for the lower percentiles up to the 60th percentile, beyond which there appears to be a worsening of WHZ over time.[8] In the rest of this paper, we only focus on the first two measures because, as with the mean, the worsening of WHZ for higher percentiles simply means that the improvements in WAZ have not been commensurate with the improvements in HAZ for those percentiles. To see distinctly the differences in the extent of improvement across different percentiles, Panel 1 and 2 of Figure 2 plots the change across the distribution of HAZ and WAZ measures between the two NFHS rounds. Table 2 provides the summary statistics for the two outcomes of interest.



Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)
Notes: a-Change in anthropometric outcome is calculated as [z-score in 2005/06 - z-score in 1992/93]. The data refer to young girls under four years of age.

Figure 2: Change in the distribution of anthropometric outcomes of rural girls

6 The null hypothesis that the distribution of HAZ in 1992/93 is equal to the distribution in 2005/06 is rejected at 1 percent level of significance using the Kolmogorov-Smirnov (KS) test of equality.

7 The null hypothesis that the distribution of WAZ in 1992/93 is equal to the distribution in 2005/06 is rejected at 1 percent level of significance using the KS test of equality.

8 The null hypothesis that the distribution of WHZ in 1992/93 is equal to the distribution in 2005/06 is rejected at 1 percent level of significance using the KS test of equality.

Table 2: Summary statistics of anthropometric outcomes of rural girls, by NFHS round

	Height-for-Age Z-scores			Weight-for-Age Z-scores		
	NFHS-1 (1992/93)	**NFHS-3 (2005/06)**	**Change[a]**	**NFHS-1 (1992/93)**	**NFHS-3 (2005/06)**	**Change[a]**
Mean z-score	-2.09 (0.02)	-1.73 (0.02)	0.37***	-1.87 (0.02)	-1.73 (0.02)	0.14***
10th Percentile	-4.48	-3.88	0.60***	-3.78	-3.5	0.28***
50th Percentile	-2.21	-1.86	0.35***	-1.87	-1.7	0.17**
90th Percentile	0.22	0.53	0.31***	-0.03	-0.04	-0.01

Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)

Notes: a-Change in anthropometric outcome is calculated as [z-score in 2005/06 - z-score in 1992/93]. The data refer to young girls under four years of age. Standard errors for mean z-score is given in parentheses; ***, ** and * indicate significance at 1, 5, and 10 percent, respectively.

The change between the two rounds shows a declining trend as we move along the two distributions from lower to higher percentiles, and is far from being constant. Clearly, the change for the lower percentiles lie outside the confidence interval for the mean change for both the anthropometric outcomes indicating that the average change is not representative of the change for the relatively undernourished girls.[9] Calculating the magnitude of change from Table 2, we find that the improvement in the mean HAZ is about 18 percent of the mean HAZ in 1992/93. However, the improvement at the 10th percentile is higher, and at the 90th percentile lower, than that at the mean. The improvements stand at 28 percent and 14 percent of the mean HAZ in 1992/93, at the 10th and 90th percentiles, respectively. The improvement in the mean WAZ is about 7 percent of the mean WAZ in 1992/93. The corresponding value at the 10th percentile is 13 percent of the mean WAZ in 1992/93, while the change is not statistically significant at the 90th percentile.

In the backdrop of the variation in changes across different percentiles of the HAZ and WAZ distributions, the first objective of this paper is to identify the principal covariates that affect the anthropometric performance of young girls in rural India at the mean, and to examine if these vary by percentiles—focusing more at the lower quantiles. The data set is the unit record data from first and third rounds of the NFHS and we use ordinary least squares (OLS) and

[9] An important point to note here is that the change is also the OLS and QR coefficient of the round dummy in a regression of HAZ and WAZ evaluated at the mean and different percentiles, without any other control. The methodology of QR coefficient is discussed later. For now we can simply see the change as the difference in the z-scores of the two rounds, at each percentile.

quantile regression (QR) to examine this question. A large set of child, mother and household specific covariates, detailed later, are used to examine whether the influence of these covariates differ over the distributions of the two outcomes in a given round, and whether at a particular percentile the influence of these covariates has changed between the two rounds. The results indicate that many of the covariates, considered, show expected signs as predictors of HAZ and WAZ outcomes. However, there is a distinct decline in the returns to many of the factors influencing child undernutrition on average, and markedly more for the WAZ distribution.

The second objective of this paper is to decompose the change in anthropometric outcomes into the "covariate effect"—attributable to change in the endowment of covariates and the "coefficient effect"—attributable to change in the returns (parameter estimates) to the covariates. The aggregate decomposition into the two effects at the mean is carried out using Oaxaca-Blinder (OB) methodology (Oaxaca, 1973; and Blinder, 1973); and Machado-Mata (MM) technique (Machado and Mata, 2005) is used to decompose the change at different percentiles. We also carry out the detailed OB decomposition of the factors contributing to the overall change in the mean HAZ and WAZ. For both HAZ and WAZ, we observe a trend of declining total change as we move up along the anthropometric distributions with significantly larger improvements for the relatively undernourished girls, but the contribution of the two effects, across the distribution, differ depending on the anthropometric outcome we consider. For the relatively undernourished, however, the improvements are driven by both the effects.

The rest of the paper is organized as follows. Section 2 presents a brief review of literature. Section 3 describes the data used in this study. Section 4 explains the methodology—the quantile regression technique, the Oaxaca-Blinder method and the Machado-Mata method of decomposition. Section 5 provides the results of the regression and the decomposition analyses. Section 6 concludes.

2. REVIEW OF LITERATURE

A large body of research documents the various covariates contributing to poor nutritional outcomes among children in India: poor health infrastructure (Paul *et al*., 2011); age clustering [10] (Griffiths *et al*., 2007); higher birth order (Mishra *et al*., 2004); declining nutritional intake (Gragnolati *et al*., 2005); poor maternal characteristics (Borooah, 2005); poor

[10] A child lives in a household which is a part of a community that operates under some state or national policy. Thus, all the levels within the societal hierarchy play a role in influencing child nutrition outcomes through genetic, behavioural and environmental factors.

economic status of the household; and poor sanitation (Spears, 2013). Although not discussed in detail, these studies guide the choice of covariates considered in this paper. The review below focuses on studies that apply decomposition techniques to study inter-group differences in child nutritional outcomes in the Indian context, most of which use the NFHS dataset.

Tarozzi and Mahajan (2007) were among the first to test for gender differences in improvements in the distribution of anthropometric outcomes using first order stochastic dominance. Using data from the first two rounds of the NFHS, they find that WHZ improved for both boys and girls, but the improvement for boys is almost double that for girls. The HAZ measure showed worsening for girls but slight improvement for boys. They also find significant regional differences in change in anthropometric performance with boys performing relatively better than girls in rural areas of North and East India. They decompose the change in the probability of stunting using the OB method and find that on average, the coefficient effect explains the entire decline in stunting observed between the two rounds and the covariate effect is insignificant. This pattern is even more dominant in rural areas. However, they do not find any gender differences in the decomposition exercise. Tarozzi (2011) updated the distributional analysis of Tarozzi and Mahajan (2007) by using the third NFHS data (2005/06). In this paper he finds that the boy advantage, as seen from greater improvement for boys in the WHZ and HAZ distribution between the first two rounds, does not extend between the second and third round of NFHS. However, he does not decompose the change observed in undernutrition as was carried in the previous paper.

A number of other studies use OB decomposition to identify factors which influence the gap in child nutritional outcomes between different groups at the mean: rural and urban gap as well as the urban poor and non-poor gap. For instance, using data from the first and third rounds of the NFHS, Kumar and Singh (2013) findings on the OB decomposition exercise on poor and non-poor urban households reveals that children belonging to poor households are undernourished due to lower utilization of health care services and poor paternal characteristics like poor health of the mother and lower parental education. Their study suggests that improving public services such as health care, and educating mothers among urban poor can purge the negative impact of poverty on childhood undernutrition. Using the same rounds of the NFHS data, Kumar and Kumari (2014) decompose the rural–urban differential in child nutrition in India over time. They find that the economic status of the household and parental education are the most significant factors explaining the widening gap.

There are a few studies in the literature which focus on comparisons of the entire distribution of outcomes. For instance, Kandpal (2011) finds that the Integrated Child Development Scheme (ICDS) significantly reduces chronic malnourishment and has significant treatment effects among the lower percentiles, an impact which becomes insignificant when based only on average outcomes.

Using OB at the mean and MM decomposition across the HAZ distribution for NFHS-3, Cavatorta *et al*. (2015) decompose the disparity in HAZ outcomes of children in rural India between Tamil Nadu (a good performer) and five other poor performing states (Bihar, Uttar Pradesh, Madhya Pradesh, Odisha and Gujarat). From the OB decomposition they conclude that most of the differential is on account of large coefficient differences between Tamil Nadu and other states, except Odisha where they find that it is the covariate difference largely that explains the difference in HAZ outcome between the two states. Their results are enriched by MM decomposition where they find that the gaps are much higher at the bottom tail of the distribution.

Bhalotra *et al*. (2010) decompose the Hindu-Muslim gap in the prevalence of stunting and wasting for all three rounds of NFHS using a non-linear decomposition method developed by Fairlie (2006). They find that 29 percent of the difference in stunting is explained by maternal education, maternal age at parturition, and child's birth year, while 20 percent of difference in wasting is explained by maternal education and state. However, this method can only be used for binary outcomes and is not applicable to study group differences in any continuous outcomes as used in this study.

This paper contributes to the literature on the analysis of child nutritional outcomes in India and addresses an important question of the drivers of the changes in undernutrition among young girls in rural India. In doing so it attempts to make use of quantile regression and decomposition techniques. Its quantile regression approach shows clearly where in the distribution the improvements have been, and how the explanatory variables have affected the outcomes at each quantile. It extends the distributional analysis done by Tarozzi and Mahajan (2007) to the decomposition exercise using the MM technique (that is, decomposing the change at different percentiles of the anthropometric distributions). Studies in the past have mainly used the OB technique to identify trends. This study, however, not only helps to identify the trends that may be missed by examining changes at means, but also examines the relative contribution of the covariate and coefficient effects across the anthropometric distributions. In addition, the focus is on rural girls which represents a marginalized section of the Indian society. Undernutrition is measured in terms of WAZ and HAZ. WAZ is a short term measure of health: deficiencies in nutrition, owing to, say, drought-like conditions, can be overcome in the short term with improved nutrition. Improvements in the longer term measure, HAZ, is harder to explain. To carry out the analysis, we use the first and third rounds of NFHS as an extension to the Tarozzi and Mahajan (2007), which used the first two rounds of NFHS data, and Tarozzi (2011) which compared the second and the third rounds.

3. CONCEPTUAL FRAMEWORK, DATA SOURCE AND VARIABLE DESCRIPTION

The conceptual framework on the drivers of child nutrition is taken from UNICEF (1998). The factors can be classified into four categories: (i) immediate causes which consists of food intakes and exposure to infectious diseases, (ii) child-specific causes which includes child feeding patterns, immunization and health care, and hygiene behavior, (iii) social and economic causes which includes household's economic status, maternal education, food availability, and lastly (iv) basic causes which includes political, economic and ideological environment, including, for example, caste. The variables included in our analysis are drawn from this framework, and also include those identified as being important in the literature reviewed above. Additionally, we include only those variables which are common to the rounds of NFHS data used in this paper. These are: child specific covariates— age (in months), birth order, percentage of the required vaccines received[11]; mother specific covariates— age at the time of first birth, education level; and household specific covariates—access to improved sources of drinking water and improved toilets, caste, household size and economic status (proxied by an indicator of asset holdings which is constructed using the weights provided for the construction of a wealth index (Smits and Steendijk, 2013)).[12]

As already stated, we use the NFHS unit record data for this analysis. The first round of NFHS was conducted in 1992/93; with subsequent rounds in 1998/99 and 2005/06, and most recently

[11] Required vaccines measure the total number of vaccines a child of a given age should receive as per the guidelines given by Indian Academy of Pediatrics Committee on Immunization (IAPCOI). Percentage of the required vaccines received is calculated based on the responses given for Polio, Diphtheria, Tetanus, Tuberculosis and Measles only. This list is not exhaustive but for consistency we use information on vaccines available for both the rounds. For a complete list of immunization and vaccines for young children see the recommendations given by IAPCOI (2008).

[12] It is the first strictly comparable asset based index which can also be used to compare economic status of households across time.

in 2015/16. The data for the fourth (latest) round is still not available for all the states. We, for this paper, use the first and the third rounds only.

There are some differences across the two rounds of NFHS considered in this paper. For instance, NFHS-1 collected anthropometric data for children below four years of age, while NFHS-3 did so for children below five years. In addition, heights were not measured for five states in NFHS-1 because of lack of appropriate height measuring tool.[13] The two rounds also differ in their definition of selection of the respondent. For NFHS-1, all married women between ages 13 and 49 were interviewed whereas for NFHS-3, all married and unmarried women between ages 15 and 49 were interviewed. Thus, to make comparisons across the two rounds, the working sample for the analysis is confined to girls below four years of age, who were born to married women between ages 15 and 49, in the states in which heights were measured in both the rounds.[14] Also, as stated earlier, the analysis is confined to rural India. The resulting sample has 17482 observations in 1992/93 and 15504 observations in 2005/06. Further, we have followed the WHO (2006) guidelines to exclude children for whom the reported anthropometric measure is not biologically feasible: namely, HAZ < (-6) and HAZ > (+6); WAZ < (-6) and WAZ > (+5); HAZ < (-3.09) and WAZ > (3.09); and WAZ < (-3.09) and HAZ > (3.09). These extreme z-scores are indicative of plausible measurement error in height and weight or data entry errors and are therefore, dropped. [15] After deleting observations with invalid anthropometric data, we are left with 10008 NFHS-1 and 8107 NFHS-3 observations on weights and 9696 NFHS-1 and 7911 NFHS-3 observations on heights.

There are also issues concerning the extent of information missing on the explanatory variables. For instance, information on vaccines received by the child is missing for 5 percent of the data. We test and find that vaccine information is completely missing at random and therefore, drop these observations from the analysis. Similarly, information on caste of the household head is missing for 372 (4.7 percent of NFHS-3 observations) observations in NFHS-3. We club them with the other backward caste (OBC) and others caste category.

[13] These states are Andhra Pradesh, West Bengal, Himachal Pradesh, Madhya Pradesh and Tamil Nadu.

[14] We exclude girls who were born to never married women which constitute 0.12 percent of the sample in 2005/06.

[15] In addition to the invalid, and therefore dropped, observations on height and weight, there is a possibility that in general the anthropometric data is measured with error. To the extent that our focus is the change over time, assuming that both survey round suffer from the same kind of measurement error, a comparison over time should not be affected by measurement error in the dependent variable.

Table 3: Summary statistics for child, mother and household covariates, by NFHS round

Covariates	**NFHS-1 (1992/93)**	**NFHS-3 (2005/06)**	**Change[a]**
Child Characteristics			
Age (in months)	22.32 (0.14)	23.10 (0.16)	0.8***
Birth order (as % of total children)			
Birth order =1	26 (0.01)	29 (0.01)	3***
Birth order =2[b]	24 (0.004)	26 (0.005)	2**
Vaccines received (as % of required vaccines)[c]	45 (0.45)	65 (0.41)	20***
Mother Characteristics			
Age at first birth (in years)	19.06 (0.03)	19.71 (0.04)	0.66***
Education (as % of all mothers):			
At most primary	16 (0.01)	15 (0.01)	-1**
Above primary[d]	19 (0.003)	36 (0.005)	17***
Household Characteristics			
Drinking Water Facility (as % of total households):			
Improved drinking water[e]	68 (0.01)	73 (0.01)	5***
Toilet Facility (as % of total households):			
Improved toilets[f]	19 (0.003)	30 (0.005)	11***
Wealth Index[g]	26.56 (0.19)	28.79 (0.24)	2.23***
Caste (as % of total households):			
Scheduled caste	14 (0.003)	17 (0.004)	3***
Scheduled tribe[h]	15 (0.003)	22 (0.005)	7***
Household Size	8 (0.04)	7 (0.03)	1***
No. of observations	9794	7787	

Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)

Notes: a- Change in covariate is calculated as [average endowment of a covariate in 2005/06 – average endowment of a covariate in 1992/93].
b- Birth order 3 or higher is the omitted category.
c- Required vaccines measure the total number of vaccines a child of a given age should receive as per the guidelines given by Indian Academy of Pediatrics Committee on Immunization (IAPCOI). For consistency, we use information available on vaccines for both the rounds and therefore, calculate the percentage based on the responses given for Polio, Diphtheria, Tetanus, Tuberculosis and Measles only. For a complete list of immunization and vaccines for young children, see IAPCOI (2008).

d- Illiterate mother is the omitted category.
e- Improved water facility takes a value 1 if drinking water is from either of the following sources: piped water, tube well, protected well or a spring, bottled water, tanker truck or a cart with small tank. It takes a value 0 for poor drinking water source (omitted) which include public well, public hand-pump, open spring, river, stream, pond, lake, dam, rainwater and 'other' as the reported category.

f- Improved toilets takes a value 1 if the household has access to a private flush or a private pit toilet. It takes a value 0 for poor toilets (omitted) which includes shared toilets, public toilets and no toilet.

g- Wealth Index is constructed using the weights given to obtain an asset based index which can be used to compare economic status of households across time (Smits and Steendijk, 2013).

h- Other backward caste (OBC) or others caste is the omitted category.
The data refer to young girls under four years of age. Standard errors reported in parentheses; ***, ** and * indicate significance at 1, 5, and 10 percent, respectively.

Table 3 provides the summary statistics of all the covariates used in this study and also shows the change in covariates between the two rounds.[16] We see substantial improvement over the thirteen year period in the mean endowment of many key covariates associated with child anthropometry.[17] The most prominent ones are: increase in the percentage of vaccines a child receives (from 45 percent to 65 percent), increase in the proportion of mothers having more than primary education relative to no education (from 19 percent to 36 percent). Improvement is also witnessed in the proportion of households having access to improved source of drinking water (from 68 percent to 73 percent), and increase in households having access to improved toilet facility (from 19 percent to 30 percent), relative to poor quality. Also, over the two rounds, the economic status of households has improved as captured by the increase in the index value over time, and the average household size has declined by one person.[18]

[16] There are covariates that should have been included in the analysis but couldn't be accounted for as sufficient data on them doesn't exist. Either they were asked in just one of the two rounds, or were completely missing from both the rounds. These include nutrient/food intakes of the child, mother's anthropometric data, policy variables and community characteristics.
[17] Test for statistical significance is done for all the covariates: Test of differences in proportions to check for change in the categorical covariates, and test for differences in means for continuous covariates.
[18] There are obvious concerns that children in our sample with valid anthropometric may constitute a biased sub-sample of all children. We compare the children with valid anthropometry and children who are dropped. Using a probit regression we find that we are likely to drop children of lower birth order, born to illiterate mothers of younger age, and more likely to come from relatively wealthier households having access to improved toilets. We do not correct for sample bias but have characterized the nature of selection which must be kept in mind while interpreting the results.

4. METHODOLOGY

4.1. QUANTILE REGRESSIONS

This section gives a brief outline of the QR method which estimates the conditional quantile function just as the OLS estimates the conditional mean function of the dependent variable. The conditional quantile regression model (Koenker and Bassett, 1978) may be written as follows:

Let $Q_\theta(x)$ for $\theta \in [0, 1]$ denote the θ^{th} conditional quantile of the distribution of anthropometric outcome, (*y*), given a vector of covariates, *x*.

The conditional quantiles are expressed as:

$$Q_\theta(x) = x'\beta_\theta \tag{1}$$

where β_θ is a vector of QR coefficients. For any $\theta \in (0, 1)$ QR coefficients, β_θ are estimated by minimizing the following objective function with respect to β:

$$n^{-1} \sum_{i=1}^{n} \quad \rho_\theta(y_i - x_i'\beta_\theta) \tag{2}$$

with

$$\rho_\theta(\mu) = \{\theta * \mu, for \mu \geq 0 (\theta - 1) * \mu, for \mu < 0 \tag{3}$$

where $\rho_\theta(\mu)$ is also known as the check function. Just like in OLS we minimize the sum of squared residuals, in QR we minimize the sum of asymmetrically or symmetrically (the case of median) weighted absolute residuals where the weights are given by the check function.

4.2. THE OAXACA-BLINDER DECOMPOSITION

We use two methods to partition the observed change in the anthropometric outcome (*y*) between the two rounds, NFHS-1 and NFHS-3 into covariate and coefficient effects. The first of the decompositions employed is the OB decomposition of the change in mean HAZ and WAZ across the two rounds. This method in the current context is explained below.

Let R denote the NFHS round, which is either R1 (NFHS-1) or R3 (NFHS-3). The dependent variable *y*, is regressed on a vector of covariates given by *x*. The underlying regression models in the two rounds can be written as follows:

$$y_i^{R3} = x_i'^{R3}\beta^{R3} + \varepsilon_i^{R3} \quad (4)$$

$$y_i^{R1} = x_i'^{R1}\beta^{R1} + \varepsilon_i^{R1} \quad (5)$$

The OLS regression for each round above yields a vector of coefficients for each round as $\hat{\beta}^{R3}$ and $\hat{\beta}^{R1}$. The change over time in the mean anthropometric outcome between the two rounds can be written as:

$$\overline{y}^{R3} - \overline{y}^{R1} = \overline{x}^{R3}\hat{\beta}^{R3} - \overline{x}^{R1}\hat{\beta}^{R1} \quad (6)$$

Adding and subtracting $\overline{x}^{R1}\hat{\beta}^{R3}$, the counterfactual anthropometric outcome, to equation (6), we get

$$\overline{y}^{R3} - \overline{y}^{R1} = \left(\overline{x}^{R3} - \overline{x}^{R1}\right)\hat{\beta}^{R3} + \overline{x}^{R1}(\hat{\beta}^{R3} - \hat{\beta}^{R1}) \quad (7)$$

where $\left(\overline{x}^{R3} - \overline{x}^{R1}\right)\hat{\beta}^{R3}$ is the covariate effect and $\overline{x}^{R1}(\hat{\beta}^{R3} - \hat{\beta}^{R1})$ is the coefficient effect.

Alternatively, adding and subtracting $\overline{x}^{R3}\hat{\beta}^{R1}$, the alternate counterfactual, the change over time can be written as:

$$\overline{y}^{R3} - \overline{y}^{R1} = \left(\overline{x}^{R3} - \overline{x}^{R1}\right)\hat{\beta}^{R1} + \overline{x}^{R3}(\hat{\beta}^{R3} - \hat{\beta}^{R1}) \quad (8)$$

where $\overline{x}^{R3}(\hat{\beta}^{R3} - \hat{\beta}^{R1})$ is the coefficient effect and $(\overline{x}^{R3} - \overline{x}^{R3})\hat{\beta}^{R1}$ is the covariate effect.

These two decompositions should give similar measurements in practical application. We construct and report the results of both the counterfactuals in the paper.

4.3. THE MACHADO AND MATA DECOMPOSITION

The MM method is an extension of the OB decomposition of the average change. The standard approach by OB method does not account for the potentially important variations in the contribution of covariate and coefficient effects at different quantiles of the distribution. This is captured in the MM decomposition which constructs a counterfactual distribution using the quantile estimates of the returns to various covariates obtained from quantile regressions. The MM decomposition method in the current context is explained as follows (Machado and Mata (2005)):

Denote by $f(y(R))$, the observed marginal density of anthropometric outcome y in round R based on the observed sample $\{y_i(R)\}$; and by $f^*(y(R))$, an estimator of the marginal density of y in round R based on the generated sample $\{y_i^*(R)\}$. The counterfactual densities will be denoted by $f^c(y(R1); x(R3))$, for the density that would result in R1 if all associated covariates were distributed as they were in R3.

We decompose the change from $f(y(R1))$ to $f(y(R3))$ into three parts:

- $f^c(y(R1); x(R3))$ with $f^*(y(R3))$: the coefficient effect;
- $f^*(y(R1))$ with $f^c(y(R1); x(R3))$: the covariate effect; and
- the residual

While such a decomposition may be constructed for any statistic, in this paper we focus on quantiles. Let q (.) be one such quantile. The decomposition of a change in q is as follows:

$$q(f(y(R1)) - q(f(y(R3)) = q(f^*(y(R1))) - q(f^c(y(R1); x(R3))) \ (\textit{covariate effect})$$

$$+ q(f^c(y(R1); x(R3))) - q(f^*(y(R3))) \ (\textit{coefficient effect})$$

$$+ \text{residual} \qquad (9)$$

The decomposition is implemented using the following steps:

Step 1: Generate a random sample of size n, say 100, from a uniform distribution U [0,1]: θ_1, $\theta_2 \ldots \theta_n$. These numbers are the quantiles to be estimated.

Step 2: For each θ from step 1, estimate the conditional quantile, $Q_\theta(x)$, yielding n estimates of the QR coefficients for the two rounds separately, i.e., $\hat{\beta}_\theta^{R1}$ and $\hat{\beta}_\theta^{R3}$.

Step 3: Generate a random sample of n individuals (with replacement) from the covariate distribution of NFHS-1 and NFHS-3 separately, i.e., x_i^{R1} and x_i^{R3} for $i=1....n$.

Step 4: Estimates of the observed distributions are given by:

$$y_i^{*R1} = x_i^{R1'} * \hat{\beta}_\theta^{R1} \qquad \text{for } i=1....n \qquad (10)$$

and

$$y_i^{*R3} = x_i^{R3'} * \hat{\beta}_\theta^{R3} \qquad \text{for } i=1....n \qquad (11)$$

Estimate of the counterfactual anthropometric distribution is given by:

$$y_i^{cR3} = x_i^{R1'} * \hat{\beta}_\theta^{R3} \quad \text{for } i=1....n \tag{12}$$

Note that another counterfactual can be estimated as:

$$y_i^{cR1} = x_i^{R3'} * \hat{\beta}_\theta^{R1} \quad \text{for } i=1....n \tag{13}$$

The first counterfactual distribution defines the anthropometric outcome of girls with NFHS-1 covariates but the returns to covariates as they were observed in NFHS-3 and the second counterfactual distribution defines the anthropometric outcome of girls with NFHS-3 covariates but the returns to covariates as they were observed in NFHS-1.

Step 5: Using the distributions calculated in step 4, the change in the estimated unconditional quantile of the anthropometric distribution between NFHS-3 and NFHS-1 can be decomposed in two alternate ways:

$$q^*(x^{R3}, \hat{\beta}_\theta^{R3}, \theta) - q^*(x^{R1}, \hat{\beta}_\theta^{R1}, \theta) \tag{14}$$

Adding and subtracting $q^c(x^{R1}, \hat{\beta}_\theta^{R3}, \theta)$, the counterfactual distribution to equation (14), we get

$$= [q^*(x^{R3}, \hat{\beta}_\theta^{R3}, \theta) - q^c(x^{R1}, \hat{\beta}_\theta^{R3}, \theta)] \ (\textit{covariate effect})$$
$$+ [q^c(x^{R1}, \hat{\beta}_\theta^{R3}, \theta) - q^*(x^{R1}, \hat{\beta}_\theta^{R1}, \theta)] \ (\textit{coefficient effect})$$
$$+ \text{residual} \tag{15}$$

Alternatively, adding and subtracting $q^c(x^{R3}, \hat{\beta}_\theta^{R1}, \theta)$, the alternate counterfactual distribution to equation (14), the change over time can be written as

$$= [q^*(x^{R3}, \hat{\beta}_\theta^{R3}, \theta) - q^c(x^{R3}, \hat{\beta}_\theta^{R1}, \theta)] \ (\textit{coefficient effect})$$
$$+ [q^c(x^{R3}, \hat{\beta}_\theta^{R1}, \theta) - q^*(x^{R1}, \hat{\beta}_\theta^{R1}, \theta)] \ (\textit{covariate effect})$$
$$+ \text{residual} \tag{16}$$

These two decompositions should give similar measurements in practical application. Results based on both the counterfactuals are reported in this paper.

However, a significant limitation of this method is that it does not quantify which covariate (or returns to it) is most important in terms of its contribution towards the aggregate covariate (or coefficient) effect. Therefore, for the disaggregate decomposition, we present the results of the OB method which allows for detailed decomposition at the mean.

5. EMPIRICAL RESULTS

5.1. ORDINARY LEAST SQUARES AND QUANTILE REGRESSION ESTIMATES OF THE CORRELATES OF ANTHROPOMETRIC OUTCOMES

We estimate 19 equidistant quantile regressions, starting from the 5th percentile up to the 95th percentile, where we regress the HAZ and WAZ measures on child, mother and household specific covariates listed in Table 3 for each round separately. Tables 4A provides the OLS and QR results for the 10th, 30th, 50th, 70th and 90th percentiles of the HAZ measure for each of the two NFHS rounds, and Table 4B presents the same for the WAZ measure.[19] The change in the OLS and QR estimates, between the two rounds, for both the outcomes is presented in Table 5. We present our results in the order of the covariates listed in Table 3, that is, we begin with child specific covariates and then move onto mother and household specific covariates. We also run regressions after controlling for location effects using state dummies. For brevity, the tables are only reported in Appendix Tables (A1A, A1B and A2).[20]

Table 4A: Mean and quantile regression estimates of height-for-age z-scores of rural girls, by NFHS round

	NFHS-1						NFHS-3					
Height-for-Age Z-score	**Mean**	**P10**	**P30**	**P50**	**P70**	**P90**	**Mean**	**P10**	**P30**	**P50**	**P70**	**P90**
Child Characteristics:												
Age	-0.12*** (	-0.11*** (0.0	-0.13*** (0.0	-0.13*** (0.0	-0.13*** (0.0	-0.13*** (0.01)	-0.11*** (0.0	-0.07*** (0.0	-0.11*** (0.0	-0.13*** (0.0	-0.14*** (0.0	-0.13***

[19] The QR results for other percentiles are available with the author. OLS standard errors are adjusted for clustering at the Primary Sampling Unit (PSU) level. QR standard errors are bootstrapped using 200 replications.

[20] A finer way to control for location effects would be to use district fixed effects. Unfortunately, district identifiers are only available for NFHS-1 and not NFHS-3. The reason for this is that NFHS-3 was designed not only to provide estimates of important indicators on family welfare, maternal and child health, and nutrition but also on HIV prevalence for which blood samples were collected. To maintain anonymity, the district identifiers were not reported.

	0.01)	1)	1)	1)	1)		1)	1)	1)	1)	1)	(0.01)
Age squared	0.17*** (0.01)	0.15*** (0.02)	0.17*** (0.01)	0.17*** (0.01)	0.18*** (0.01)	0.18*** (0.02)	0.16*** (0.01)	0.09*** (0.02)	0.16*** (0.01)	0.19*** (0.01)	0.20*** (0.01)	0.19*** (0.03)
Birth order 1	0.07 (0.05)	0.07 (0.07)	0.01 (0.06)	0.05 (0.05)	0.05 (0.05)	0.10 (0.10)	0.04 (0.05)	0.18** (0.08)	0.09 (0.06)	0.06 (0.05)	0.00 (0.06)	-0.23** (0.11)
Birth order 2	0.02 (0.05)	-0.01 (0.07)	0.01 (0.06)	0.05 (0.05)	0.07 (0.05)	-0.04 (0.10)	0.05 (0.05)	0.14* (0.08)	0.02 (0.06)	0.04 (0.05)	0.02 (0.06)	-0.11 (0.11)
Vaccines	0.002*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.002*** (0.001)	0.001*** (0.001)	-0.002** (0.001)	0.001** (0.001)	0.004*** (0.001)	0.003*** (0.001)	0.001** (0.001)	-0.001 (0.001)	-0.004*** (0.001)
<u>*Mother Characteristics:*</u>												

Age at first birth	0.03*** (0.01)	0.01 (0.01)	0.03*** (0.01)	0.04*** (0.01)	0.04*** (0.01)	0.04*** (0.01)	0.02*** (0.01)	0.01 (0.01)	0.03*** (0.01)	0.02*** (0.01)	0.02*** (0.01)	0.02 (0.01)
Education: At most primary	0.15*** (0.05)	0.37*** (0.08)	0.31*** (0.07)	0.20*** (0.05)	0.15** (0.06)	-0.11 (0.11)	0.12** (0.06)	0.22** (0.09)	0.16** (0.07)	0.13** (0.06)	0.06 (0.07)	0.07 (0.13)
Education: Above primary	0.34*** (0.06)	0.47*** (0.08)	0.47*** (0.07)	0.37*** (0.06)	0.48*** (0.07)	0.18 (0.12)	0.25*** (0.05)	0.53*** (0.08)	0.29*** (0.06)	0.24*** (0.06)	0.21*** (0.06)	0.21* (0.12)
<u>*Household Characteristics:*</u>												
Improved drinking water	0.04 (0.05)	-0.01 (0.06)	-0.08 (0.05)	-0.07 (0.04)	0.04 (0.05)	0.30*** (0.09)	-0.25*** (0.05)	-0.19** (0.07)	-0.21*** (0.05)	-0.27*** (0.05)	-0.33*** (0.06)	-0.31*** (0.11)
Improved toilet	0.08 (0.07)	0.08 (0.08)	0.10 (0.07)	0.10** (0.06)	0.11** (0.07)	0.06 (0.12)	0.10 (0.06)	0.01 (0.09)	0.13** (0.06)	0.10** (0.06)	0.09 (0.07)	0.04 (0.13)

Wealth Index	0.007*** (0.002)	0.007*** (0.002)	0.010*** (0.002)	0.008*** (0.001)	0.005*** (0.002)	0.004 (0.003)	0.011*** (0.001)	0.012*** (0.002)	0.011*** (0.002)	0.011*** (0.002)	0.012*** (0.002)	0.013*** (0.002)
SC	-0.05 (0.06)	-0.02 (0.08)	-0.06 (0.07)	-0.09* (0.05)	-0.08 (0.06)	-0.19 (0.12)	-0.12** (0.06)	-0.23*** (0.08)	-0.13** (0.06)	-0.11* (0.06)	-0.10 (0.07)	-0.10 (0.12)
ST	0.32*** (0.08)	-0.05 (0.08)	0.22*** (0.07)	0.24*** (0.05)	0.33*** (0.06)	0.67*** (0.11)	0.19*** (0.06)	0.02 (0.08)	0.05 (0.06)	0.08 (0.06)	0.16*** (0.06)	0.49*** (0.12)
HH Size	-0.01** (0.00)	-0.02** (0.01)	-0.02*** (0.01)	-0.02*** (0.00)	-0.01 (0.01)	0.01 (0.01)	-0.0* (0.01)	-0.01 (0.01)	-0.01* (0.01)	-0.02** (0.01)	-0.02** (0.01)	-0.00 (0.01)
Constant	-1.53*** (0.14)	-3.33*** (0.19)	-2.25*** (0.16)	-1.53*** (0.13)	-0.83*** (0.15)	0.50* (0.28)	-0.99*** (0.15)	-3.73*** (0.22)	-2.33*** (0.16)	-1.07*** (0.15)	0.10 (0.17)	1.69*** (0.32)
Observations	94	94	94	94	94	9489	75	75	75	75	75	75

	89	89	89	89	89	98	98	98	98	98	98

Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)
Notes: The data refer to young girls under four years of age. Base category is rural girl of birth order 3 or more born to an illiterate mother, who was married in an OBC or others caste category household having poor drinking water and poor toilet facilities. Robust standard errors clustered at the PSU level are reported in parentheses for OLS. QR standard errors in parentheses are bootstrapped using 200 replications; ***, ** and * indicate significance at 1, 5, and 10 percent, respectively.

Table 4B: Mean and quantile regression estimates of weight-for-age z-scores of rural girls, by NFHS round

	NFHS-1						NFHS-3					
Weight-for-Age Z-score	**Mean**	**P10**	**P30**	**P50**	**P70**	**P90**	**Mean**	**P10**	**P30**	**P50**	**P70**	**P90**
<u>*Child Characteristics:*</u>												
Age	-0.06*** (0.01)	-0.06*** (0.01)	-0.05*** (0.01)	-0.05*** (0.00)	-0.05*** (0.01)	-0.06*** (0.01)	-0.04*** (0.00)	-0.05*** (0.01)	-0.04*** (0.01)	-0.04*** (0.01)	-0.04*** (0.01)	-0.05*** (0.01)
Age squared	0.08*** (0.01)	0.09*** (0.02)	0.07*** (0.01)	0.07*** (0.01)	0.07*** (0.01)	0.08*** (0.02)	0.05*** (0.01)	0.07*** (0.02)	0.05*** (0.01)	0.05*** (0.01)	0.05*** (0.01)	0.06*** (0.01)
Birth order 1	0.07* (0.04	0.11* (0.07	0.12** (0.0	0.05 (0.04)	0.05 (0.05)	0.00 (0.07)	0.04 (0.04)	0.18** (0.0	0.06 (0.05)	0.06 (0.05)	0.03 (0.05)	-0.06 (0.06

	)	)	5)					8)				)
Birth order 2	0.02 (0.04)	0.11 (0.07)	0.04 (0.05)	0.00 (0.04)	0.02 (0.05)	-0.07 (0.07)	0.01 (0.04)	0.14* (0.08)	0.04 (0.05)	0.03 (0.05)	0.05 (0.05)	-0.04 (0.06)
Vaccines	0.001** (0.001)	0.003*** (0.001)	0.002*** (0.001)	0.001*** (0.001)	0.001 (0.001)	-0.002** (0.001)	0.001* (0.001)	0.004*** (0.001)	0.002*** (0.001)	0.001 (0.001)	0.003 (0.001)	-0.003*** (0.001)
Mother Characteristics:												
Age at first birth	0.03*** (0.01)	0.03*** (0.01)	0.02*** (0.01)	0.02*** (0.01)	0.03*** (0.01)	0.04*** (0.01)	0.02*** (0.00)	0.01 (0.01)	0.02*** (0.01)	0.02*** (0.01)	0.02*** (0.01)	0.02*** (0.01)
Education: At most primary	0.15*** (0.05)	0.31*** (0.08)	0.24*** (0.05)	0.17*** (0.05)	0.13** (0.05)	-0.03 (0.09)	0.09* (0.05)	-0.02 (0.09)	0.13** (0.06)	0.09 (0.05)	0.03 (0.05)	0.03 (0.07)

Education: Above primary	0.36*** (0.05)	0.49*** (0.09)	0.42*** (0.06)	0.40*** (0.05)	0.38*** (0.06)	0.22** (0.09)	0.23*** (0.04)	0.28*** (0.08)	0.27*** (0.05)	0.22*** (0.05)	0.19*** (0.05)	0.17*** (0.06)
Household Characteristics:												
Improved drinking water	-0.05 (0.04)	-0.08 (0.07)	-0.13*** (0.04)	-0.08** (0.04)	-0.02 (0.04)	0.06 (0.07)	-0.18*** (0.04)	-0.16** (0.07)	-0.13*** (0.05)	-0.17*** (0.04)	-0.20*** (0.04)	-0.24*** (0.05)
Improved toilet	0.22*** (0.05)	0.28*** (0.09)	0.28*** (0.06)	0.25*** (0.05)	0.22*** (0.06)	0.05 (0.09)	0.08* (0.05)	0.12 (0.09)	0.11* (0.06)	0.08 (0.05)	0.03 (0.05)	-0.02 (0.07)
Wealth Index	0.006*** (0.001)	0.009*** (0.002)	0.008*** (0.001)	0.006*** (0.001)	0.004*** (0.001)	0.006** (0.002)	0.012*** (0.001)	0.012*** (0.001)	0.010*** (0.001)	0.010*** (0.001)	0.011*** (0.001)	0.015*** (0.001)
SC	-0.10*	-0.12 (	-0.06 (	-0.12*	-0.08 (	-0.17**	-0.15*	-0.30*	-0.16*	-0.14*	-0.12*	-0.11*

	(0.05)	0.08)	0.05)	*(0.05)	0.05)	(0.09)	**(0.04)	**(0.08)	**(0.05)	**(0.05)	*(0.05)	(0.06)
ST	0.36***(0.06)	0.11(0.08)	0.29***(0.05)	0.32***(0.05)	0.36***(0.05)	0.59***(0.09)	0.09*(0.05)	-0.17**(0.08)	0.09*(0.05)	0.10**(0.05)	0.20***(0.05)	0.23***(0.06)
HH Size	-0.01*(0.00)	-0.02***(0.01)	-0.01**(0.00)	-0.01**(0.00)	0.00(0.00)	-0.00(0.01)	-0.01**(0.01)	-0.01(0.01)	-0.02***(0.01)	-0.01**(0.01)	-0.01*(0.01)	-0.01(0.01)
Constant	-1.99***(0.12)	-3.88***(0.20)	-2.71***(0.13)	-1.88***(0.11)	-1.42***(0.13)	-0.44**(0.21)	-1.85***(0.12)	-3.72***(0.22)	-2.60***(0.14)	-1.85***(0.13)	-1.16***(0.13)	0.08(0.16)
Observations	9794	9794	9794	9794	9794	9794	7787	7787	7787	7787	7787	7787

Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)
Notes: The data refer to young girls under four years of age. Base category is rural girl of birth order 3 or more born to an illiterate mother, who was married in an OBC or other category household having poor drinking water and poor toilet facilities. Robust standard errors clustered at the PSU level are reported in parentheses for OLS. QR standard errors in parentheses are bootstrapped using 200 replications; ***, ** and * indicate significance at 1, 5, and 10 percent, respectively.

Table 5: Change[a] in mean and quantile regression estimates of anthropometric outcomes of rural girls between 1992/93 and 2005/06

	Change in Height-for-Age Z-scores						Change in Weight-for-Age Z-scores					
	Mean	**P10**	**P30**	**P50**	**P70**	**P90**	**Mean**	**P10**	**P30**	**P50**	**P70**	**P90**
Child Characteristics:												
Age	0.01 (0.01)	0.04*** (0.01)	0.02* (0.01)	0.003 (0.01)	-0.004 (0.01)	-0.01 (0.02)	0.02** (0.01)	0.01 (0.01)	0.02* (0.01)	0.02** (0.01)	0.01 (0.01)	0.01 (0.01)
Age squared	-0.000 (0.02)	-0.06** (0.03)	-0.01 (0.02)	0.02 (0.02)	0.02 (0.02)	0.01 (0.04)	-0.03** (0.01)	-0.02 (0.02)	-0.02 (0.02)	-0.03* (0.01)	-0.02 (0.02)	-0.03 (0.02)
Birth order 1	-0.03 (0.07)	0.13 (0.11)	0.07 (0.09)	0.02 (0.07)	-0.04 (0.08)	-0.28* (0.15)	0.03 (0.06)	0.07 (0.12)	-0.05 (0.07)	0.08 (0.06)	-0.03 (0.07)	-0.07 (0.10)
Birth order 2	0.02 (0.07)	0.18* (0.11)	0.01 (0.08)	-0.01 (0.07)	-0.06 (0.09)	-0.03 (0.13)	-0.001 (0.05)	0.002 (0.10)	-0.02 (0.07)	0.04 (0.07)	0.01 (0.07)	0.01 (0.10)
Vaccines	-0.002* (0.001)	-0.001 (0.001)	-0.000 (0.001)	-0.001 (0.001)	-0.002** (0.001)	-0.002 (0.002)	0.000 (0.001)	0.001 (0.001)	-0.000 (0.001)	-0.001 (0.001)	-0.000 (0.001)	-0.001 (0.001)
Mother Characteristics:												
Age at first birth	-0.01 (0.01)	0.01 (0.02)	-0.000 (0.01)	-0.01 (0.01)	-0.02 (0.01)	-0.02 (0.02)	-0.01 (0.01)	-0.01 (0.01)	-0.004 (0.01)	-0.001 (0.01)	-0.01 (0.01)	-0.02* (0.01)
Education: At most primary	-0.03 (0.07)	-0.14 (0.13)	-0.13 (0.10)	-0.08 (0.08)	-0.09 (0.09)	0.15 (0.17)	-0.07 (0.06)	-0.31*** (0.12)	-0.09 (0.08)	-0.08 (0.06)	-0.08 (0.07)	0.05 (0.09)
Education: Above primary	-0.08 (0.08)	0.07 (0.13)	-0.15* (0.09)	-0.13* (0.07)	-0.27*** (0.09)	-0.03 (0.16)	-0.14** (0.06)	-0.19* (0.12)	-0.14* (0.08)	-0.20*** (0.06)	-0.17** (0.07)	-0.09 (0.10)
Household Characteristics:												
Improved drinking water	-0.28*** (0.07)	-0.13 (0.10)	-0.13* (0.08)	-0.21*** (0.07)	-0.36*** (0.07)	-0.58*** (0.15)	-0.13** (0.06)	-0.07 (0.10)	-0.02 (0.07)	-0.11* (0.06)	-0.18** (0.06)	-0.31*** (0.09)
Improved toilet	0.01 (0.07)	-0.05 (0.14)	0.03 (0.10)	0.001 (0.08)	-0.03 (0.09)	0.05 (0.17)	-0.13** (0.06)	-0.14 (0.13)	-0.17** (0.08)	-0.17** (0.07)	-0.19*** (0.06)	-0.06 (0.10)
Wealth index	0.004*** (0.002)	0.003 (0.003)	0.002 (0.002)	0.003* (0.002)	0.007*** (0.002)	0.009** (0.004)	0.01*** (0.001)	0.002 (0.003)	0.003* (0.001)	0.004*** (0.002)	0.007*** (0.001)	0.009*** (0.003)

SC	-0.07 (0.08)	-0.19* (0.11)	-0.05 (0.10)	-0.01 (0.08)	-0.04 (0.09)	0.08 (0.18)	-0.06 (0.06)	-0.17 (0.13)	-0.11* (0.07)	-0.03 (0.07)	-0.04 (0.07)	0.04 (0.10)
ST	-0.12 (0.08)	0.09 (0.13)	-0.15* (0.09)	-0.14* (0.08)	-0.14 (0.09)	-0.16 (0.21)	-0.26*** (0.06)	-0.25** (0.13)	-0.20** (0.09)	-0.22*** (0.07)	-0.18** (0.07)	-0.32*** (0.13)
Household size	0.001 (0.01)	0.01 (0.01)	0.001 (0.01)	0.001 (0.01)	-0.01 (0.01)	-0.02 (0.02)	-0.002 (0.01)	0.02* (0.01)	-0.004 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.003 (0.01)
Constant	0.54*** (0.22)	-0.47 (0.34)	-0.03 (0.25)	0.48** (0.23)	0.93*** (0.23)	1.24*** (0.42)	0.13 (0.15)	0.11 (0.32)	0.09 (0.17)	0.06 (0.19)	0.25 (0.19)	0.44 (0.28)

Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)

Notes: a- Change in returns is calculated as $(\hat{\beta}^{R3} - \hat{\beta}^{R1})$.
The data refer to young girls under four years of age. Base category is rural girl of birth order 3 or more born to an illiterate mother, who was married in an OBC or others caste category household having poor drinking water and poor toilet facilities. Robust standard errors clustered at the PSU level are reported in parentheses for OLS. QR standard errors in parentheses are bootstrapped using 200 replications; ***, ** and * indicate significance at 1, 5, and 10 percent, respectively.

As seen from the tables, both the anthropometric outcomes have a convex relationship with the age of the child: decreasing initially with age and then increasing throughout the distribution. This is seen for both the rounds.

The coefficient of having a lower birth order, say for instance, being first born relative to a birth order of 3 or more, show no association across the HAZ distribution for the two rounds except for the 10^{th} and 90^{th} percentile in 2005/06. Being of a lower birth has a significant positive effect on the height of a severely stunted child but has a negative effect on an extremely tall child. For WAZ, on the other hand, the coefficient show positive effect at the mean and till the 30^{th} percentile. This, however, remain significant till the 10^{th} percentile only as we move to the 2005/06 distribution Looking at the change in Table 5, the coefficient at the 90^{th} percentile for HAZ, representing relatively tall girls, suggests significant deterioration in the returns to having a lower birth order.

Increase in the percentage of vaccines received has a positive effect on HAZ and WAZ in at least the lower-than median percentiles and at the mean, but the magnitude of the coefficients is very small to have any meaningful interpretation (Table 5).

Maternal characteristics like mother being older at the time of birth of her first child and better education, for instance, having more than primary (above primary education covariate) education relative to no education, positively predicts the anthropometric outcomes across much of the distribution for NFHS-1 and NFHS-3 except at some extreme percentiles where the coefficients are insignificant (for example, the coefficient of the former covariate is insignificant at the 10th percentile of the WAZ distribution in NFHS-3. For HAZ, it is insignificant at the 10th percentile in both NFHS-1 and NFHS-3). However, the returns to the mother's education significantly declined for the WAZ indicator at the mean and across percentiles except at the 90th percentile. For the HAZ indicator also the decline in returns is observed between the 30th and 70th percentiles and this is not picked up by the mean change (see Table 5).

Unexpectedly, the impact of household's access to improved source of drinking water on the anthropometric outcomes is negative across the 2005/06 distribution. Referring to Table 5, we find that the returns to household's access to improved drinking water has further worsened at the mean and for the relatively nourished girls (the negative change is significant at the median and higher percentiles for both HAZ and WAZ). In addition to this, the worsening in HAZ is also seen for the moderately stunted girl (30th percentile of HAZ in Table 5)

Household characteristics like access to improved toilets (relative to poor or no toilets) and higher economic status are positively associated with the anthropometric outcomes, but the coefficients are insignificant at few percentiles. Looking whether the change is significant in Table 5, we find that the return to improved toilets declined over time across the WAZ distribution, except for the extreme bottom and top 10 percent of the distribution. The returns to household wealth show a statistical increase over time for the two outcomes at the mean and for most of the higher percentiles, however, the magnitude of change is very small to have any meaningful economic interpretation.

The coefficient of scheduled caste (SC) dummy (relative to other backward caste (OBC) and 'others' caste category) shows a negative association with the anthropometric outcomes (when significant), which is not unexpected given that SC's are considered to be a disadvantaged group of the Indian society. The negative association is seen to be stronger in NFHS-3, but the change between the two rounds is not significant except for the negative change witness by extremely stunted girls born in SC households (see the coefficient at the 10th percentile in the HAZ panel in Table 5) and moderately underweight girls born in SC households (see the coefficient at the 30th percentile in the WAZ panel in Table 5).

Interestingly, the household head belonging to scheduled tribe (ST) (relative to OBC and 'others' caste group) shows a positive association at the mean for both the outcomes across the two rounds indicating that ceteris paribus, girls born to this marginalized group, relative to those belonging to OBC and 'others' caste group, on average are associated with a higher HAZ and WAZ. Looking at the coefficients across percentiles, we find that in 2005/06, the coefficient for WAZ is negative at the 10th percentile and is insignificant for HAZ for the bottom half of the distribution. Between the two rounds, we observe a sharp decline in the returns to ST dummy at the mean and across the WAZ distribution as seen in Table 5. The returns have also declined between the 30th and 50th percentile of the HAZ distribution. At this point it is advantageous to discuss the parameters estimates of ST dummy when state fixed effects are included in Appendix Tables (A1A, A1B and A2).[21] We find that on the inclusion of the state dummies, the coefficient on ST dummy is insignificant for the two outcome indicators except for the positive coefficient at the mean and through the 30th and 50th percentiles of HAZ in NFHS-1 (Table A1A and A1B). We find no significant change in the coefficient value between the two rounds for either of the two anthropometric indicators (A2).

Looking at the coefficient on the individual state dummies, we find that at least for WAZ, the change in coefficient value is always negative relative to Jammu and Kashmir (the omitted category), whenever significant. The only exception is Arunachal Pradesh where we see a positive change in the coefficient at the mean and 50th percentile. This trend is seen for tribal as well as non-tribal states (Table A2).[22] For the HAZ distribution, we see a mixed pattern in the change in coefficient; for some states it is positive, for some it is negative.

An increase in the number of members living in the household has a worsening effect on the height and weight outcomes. This is seen at the mean and at least for the bottom; half of the distribution for the two outcomes. The coefficients are similar in the two rounds and show no significant change (Table 5). This is not surprising since for a larger household, the resources are allocated among a larger number of people. The decrease in per capita money spent matters more for individuals who are relatively undernourished.

[21] The results of other covariates remain consistent when we control for state differences (Appendix Tables (A1A, A1B and A2)).

[22] The following constitute the tribal population dominated states for our sample: "The Seven Sister States" in the North East of India (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura), Orissa and Bihar (includes Jharkhand).

The coefficients associated with the intercept term, which picks up the effect of all other covariates not included in the model, suggest a positive change, but this too is seen at the mean for the higher percentiles of the HAZ indicator. For the WAZ indicator, on the other hand, the change in the intercept is not statistically significant.

While the OLS and QR exercise was carried out to identify the covariates associated with higher improvements seen in the lower percentiles of the HAZ and WAZ distributions, the results suggest the opposite instead. We observe a significant decline in the return to many of the key covariates—mainly for the WAZ distribution. These include the following: more than primary education of the mother (relative to no education), having access to improved toilets (relative to poor quality) and belonging to ST (relative to OBC and 'others' caste category). In the next section, we present the results on the decomposition exercise to understand what drives the improvements witnessed in the anthropometric outcomes.

5.2 THE AGGREGATE OAXACA-BLINDER DECOMPOSITION RESULTS

Table 6 presents the aggregate OB decomposition exercise for HAZ and WAZ based on the counterfactual constructed using the 2005/06 coefficients (NFHS-3) and the covariates as they were in 1992/93 (NFHS-1).[23]

Starting with HAZ, in the aggregate, the coefficient effect seems to have a greater role in explaining the mean change in the HAZ between the two rounds relative to the covariate effect. Looking at the respective contribution of the two effects to the total change, we see that the improvement in the endowment of several covariates that are positively associated with HAZ taken together account for only 20 percent of the total change, holding the return to these covariates constant at 2005/06 levels across both years, and the remaining 80 percent is explained by the change in the returns to the covariates.

Table 6: The aggregate Oaxaca-Blinder decomposition using 2005/06 coefficients to create the counterfactual

	Change in Height-for-Age Z-score		**Change in Weight-for-Age Z-score**	
	Estimate	**% of Total Change**	**Estimate**	**% of Total Change**
Covariate Effect	0.07^{***} (0.02)	20	0.10^{***} (0.02)	71
Coefficient Effect	0.29^{***} (0.04)	80	0.04 (0.03)	29

[23] Standard errors are adjusted for clustering at the PSU level.

Total Change[a]	0.36*** (0.04)	0.14*** (0.03)
Observations	**17087**	**17581**

Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)
Notes: a- Change is calculated as [Estimates in 2005/06 - Estimates in 1992/93]].
The data refer to young girls under four years of age. Robust standard errors clustered at the PSU level are reported in parentheses; ***, ** and * indicate significance at 1, 5, and 10 percent, respectively.

The finding of a dominant coefficient effect is, however, not seen in the decomposition of WAZ measure. In fact, the covariate effect is responsible for the entire change in mean WAZ— explaining 71 percent of the total change; the coefficient effect is insignificant. In other words, the change in mean WAZ is entirely due to improvement in the endowment of covariates associated with improving WAZ.[24]

5.3. THE MACHADO AND MATA DECOMPOSITION RESULTS

Tables 7 summarizes the results of the MM decomposition of the change in HAZ and WAZ for the nine deciles using the 2005/06 coefficients to construct the counterfactual distribution; a graphical representation of which is in Figure 3.[25]

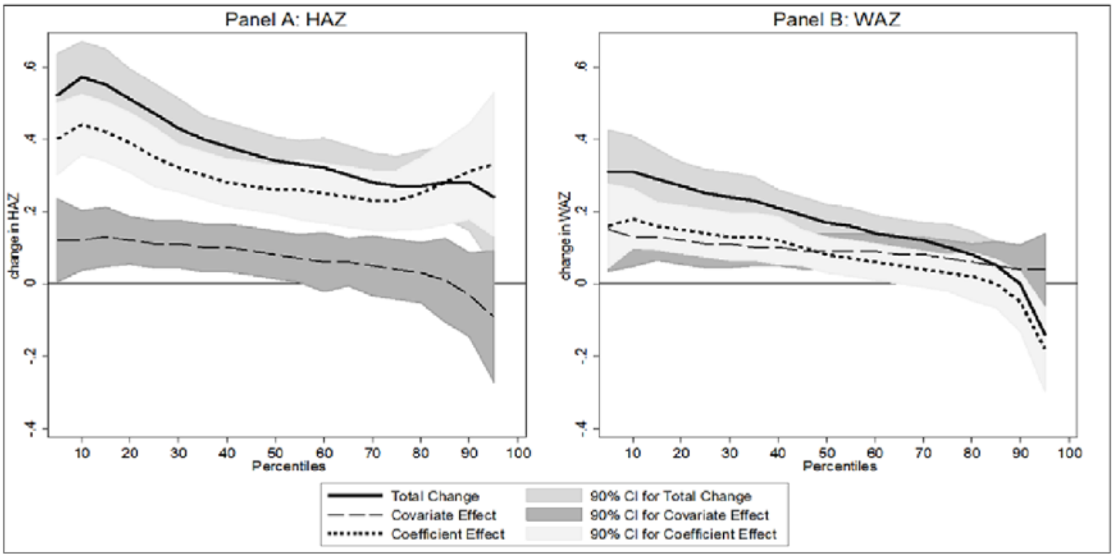
Table 7: The Machado-Mata decomposition using 2005/06 coefficients to create the counterfactual distribution

	Change in Height-for-Age Z-scores					**Change in Weight-for-Age Z-scores**				
		Covariate Effect		**Coefficient Effect**			**Covariate Effect**		**Coefficient Effect**	
Percentile	**Total Change[a]**	**Estimate**	**% of Total Change**	**Estimate**	**% of Total Change**	**Total Change[a]**	**Estimate**	**% of Total Change**	**Estimate**	**% of Total Change**
10	0.56***	0.12**	22	0.44***	78	0.27***	0.13***	49	0.14***	51
	(0.06)	(0.05)		(0.08)		(0.07)	(0.07)		(0.06)	

[24] The broad conclusion on the components of aggregate change in mean HAZ and WAZ is unchanged if the 1992/93 coefficients are used to create the counterfactual instead. Therefore, the results for the same is provided in the Appendix Table A2.3.
[25] Standard errors are bootstrapped using 200 replications.

20	0.51***	0.13***	25	0.38***	75	0.26***	0.14***	53	0.12***	47
	(0.05)	(0.04)		(0.08)		(0.05)	(0.06)		(0.06)	
30	0.43***	0.11***	26	0.32***	74	0.25***	0.13***	52	0.12***	48
	(0.04)	(0.04)		(0.06)		(0.04)	(0.04)		(0.05)	
40	0.37***	0.10**	27	0.27***	73	0.22***	0.12***	54	0.10***	46
	(0.04)	(0.04)		(0.05)		(0.03)	(0.04)		(0.03)	
50	0.34***	0.10**	30	0.24***	70	0.19***	0.11***	60	0.08***	40
	(0.04)	(0.04)		(0.04)		(0.03)	(0.03)		(0.03)	
60	0.31***	0.08	25	0.23***	75	0.16***	0.10***	62	0.06**	38
	(0.04)	(0.04)		(0.05)		(0.03)	(0.03)		(0.02)	
70	0.28***	0.07	25	0.21***	75	0.13***	0.09***	71	0.04	29
	(0.04)	(0.04)		(0.04)		(0.03)	(0.03)		(0.04)	
80	0.27***	0.04	13	0.23***	27	0.10**	0.09**	87	0.01	13
	(0.04)	(0.05)		(0.05)		(0.03)	(0.03)		(0.04)	
90	0.28***	-0.03	-9	0.31***	109	0.02	0.07	302	-0.05	-202
	(0.06)	(0.08)		(0.08)		(0.04)	(0.04)		(0.04)	

Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)
Notes: a- Change is calculated as [Estimates in 2005/06 - Estimates in 1992/93]
The data refer to young girls under four years of age. Standard errors in parentheses are bootstrapped using 200 replications; ***, ** and * indicate significance at 1, 5, and 10 percent, respectively.



Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)
Notes: The data refer to young girls under four years of age. The 90 percent confidence bands are obtained using the bootstrap technique (200 replications).

Figure 3: The Machado-Mata decomposition using 2005/06 coefficients to create the counterfactual distribution

Looking at the column for total change in the HAZ measure, we see that the improvement between the two rounds is highest at the 10th percentile and falls thereafter: from 0.56 SD at the 10th percentile to 0.34 SD at the median and 0.28 SD at the 90th percentile. The proportion of the change due to coefficient effect is high and relatively stable, between 70 and 78 percent across much of the distribution (up to the 70th percentile). Correspondingly, the covariate effect explains approximately 30 percent of the change for the bottom half of the HAZ distribution and becomes insignificant beyond the median. Note that both the total change and the coefficient effect get smaller as we move to higher percentiles, but are significant throughout the HAZ distribution. By and large, however, these results are in consonance with the OB decomposition which indicates that changes in the returns to covariates explain much of the improvement in HAZ; and improvements in covariates—to the extent they matter—only do so for stunted girls.

Similar to the HAZ outcome, the change in WAZ decreases from 0.27 SD at the 10th percentile to 0.19 SD at the median and then becomes insignificant at the 90th percentile. Unlike the case with the OB decomposition where the improvement in WAZ was almost entirely explained by the covariate effect, results from the MM decomposition indicates that at least for the bottom half of the distribution, the coefficient effect contributes as much as the covariate effect in explaining the overall change (the dashed curve for covariate effect lies within the confidence band for the coefficient effect in Panel B of Figure 3).It is clearly seen from the table that the coefficient effect is significantly different from zero till the 60th percentile, beyond which it turns insignificant. Note that the total change in WAZ is also insignificant beyond the 80th percentile—this is not surprising as these are already well-nourished children. This indicates that the coefficient effect at the mean is not representative of the effect of change in returns for the relatively underweight girls (for the lower percentiles).[26]

Thus far, the discussion has focused on the aggregate decomposition of the change in anthropometric outcomes into coefficient and covariate effects. To assess which specific covariates and associated coefficients account for these patterns, we turn to a more disaggregated decomposition in the next section. However, the focus is only the average change, as the covariate-specific analysis at different quantiles (using recentered influence function (RIF) technique developed by Firpo *et al*., (2009)) is beyond the scope of this study.[27]

5.4. THE DISAGGREGATE OAXACA-BLINDER DECOMPOSITION RESULTS

Table 8 presents findings from the detailed decomposition exercise for HAZ and WAZ using the OB method. We use the same counterfactual as used in the discussion of results of aggregate OB, that is, 2005/06 coefficients combined with 1992/93 covariates.[28]

Table 8: The disaggregate Oaxaca-Blinder decomposition using 2005/06 coefficients to create the counterfactual

	Change in Height-for-Age Z-scores	Change in Weight-for-Age Z-scores

[26] As noted in the Section 4.3, another set of estimates could be obtained using 1992/93 counterfactual. The results are similar and therefore, are presented in Appendix Table A4 and Appendix Figure A1.

[27] RIF technique allows for detailed decomposition just like OB. Also, RIF technique generates estimates of unconditional quantile estimates, whereas QR provides conditional quantile estimate. Thus, one can also estimate the marginal effect of the covariates on the unconditional quantile estimates.

[28] The results of the alternative counterfactual are analogous and are presented in the Appendix Table A5.

	Covariate Effect		Coefficient Effect		Covariate Effect		Coefficient Effect	
	Estimate	**% of Total Change**	**Estimate**	**% of Total Change**	**Estimate**	**% of Total Change**	**Estimate**	**% of Total Change**
Child Characteristics:								
Age	-0.04*** (0.01)	-10	0.18** (0.09)	49	-0.01*** (0.00)	-9	0.16** (0.07)	116
Birth order	0.00 (0.00)	1	-0.00 (0.03)	-1	0.00 (0.00)	1	-0.01 (0.02)	-6
Vaccines	0.01 (0.01)	2	-0.06* (0.04)	-18	0.02* (0.01)	12	;-0.00 (0.03)	-1
Mother's Characteristics:								
Age at first birth	0.01*** (0.00)	4	-0.24 (0.16)	-65	0.01*** (0.00)	8	-0.18 (0.13)	-130
Education	0.04*** (0.01)	11	-0.02 (0.02)	-6	0.04*** (0.01)	28	-0.04* (0.02)	-26
Household's Characteristics:								
Improved drinking water	-0.01*** (0.00)	-3	-0.19*** (0.05)	-53	-0.01*** (0.00)	-6	-0.09** (0.04)	-63
Improved toilet	0.01 (0.01)	3	0.00 (0.02)	1	0.01* (0.01)	7	-0.03* (0.01)	-19
Wealth Index	0.03*** (0.01)	7	0.11** (0.06)	30	0.03*** (0.01)	21	0.15*** (0.05)	113
SC/ST	0.01 (0.01)	2	-0.03 (0.02)	-8	0.00 (0.00)	1	-0.05*** (0.02)	-34
HH Size	0.01 (0.01)	3	0.01 (0.07)	2	0.01 (0.01)	8	-0.03 (0.05)	-20
Constant			0.54*** (0.20)	149			0.13 (0.17)	99
Total Change[a]	0.07*** (0.02)	20	0.29*** (0.04)	80	0.10*** (0.02)	71	0.04 (0.03)	29
Observations		**17087**				**17581**		

Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)
Notes: a- Change is calculated as [Estimates in 2005/06 - Estimates in 1992/93]
The data refer to young girls under four years of age. Robust standard errors clustered at the PSU level are reported in parentheses; ***, ** and * indicate significance at 1, 5, and 10 percent, respectively.

Considering HAZ first, aggregate covariate effect stands at 20 percent, bulk of which is coming from improvements in mother's education and household wealth. A perverse sign is seen on the variables representing child's age and access to improved sources of drinking water. Likewise, the aggregate coefficient effect, although large, consists of a mix of offsetting positive and negative coefficient effects for individual covariates with the intercept capturing the bulk of the effect. It is hard to interpret what the change in intercept implies as it is a residual category, and might be picking up a change in the returns to factors which have not been identified in the model.

Turning to the disaggregated decomposition of the change in mean WAZ, the contribution of the aggregate covariate effect is 71 percent which is largely coming from the favourable change in the endowment of the following covariates: improvement in the vaccine environment, increase in the age of the mother at the time of first birth, increase in mother's education, improved toilets and household wealth.

The aggregate coefficient effect is insignificant, but this does not imply that contributions of individual covariates to total change are insubstantial. In fact, we observe negative contributors cancelling out the effect of positive contributors and making the overall effect insignificant: the negative contributions of mother's education and household level sanitation and caste variables nullifies the positive and strong effect of change in returns to child's age and household wealth.

The decomposition exercise, thus, provides an understanding as to what is driving the improvement in the height and weight outcomes among rural girls in India- whether it is endowment differences between the two rounds of the variables commonly used in explaining nutritional outcomes (covariate effect), or it is the differential strength of relationships across the two rounds between child health and the nutrition-related endowments (coefficient effect)? From the Oaxaca Blinder method we find improvement in the vaccine environment, increase in the age of the mother at the time of first birth, increase in mother's education, improved toilets and household wealth are responsible for a fairly large part of the substantial improvements in WAZ (covariate differences). For HAZ, on the other hand, the predominant effect of a larger intercept (largest contributor to HAZ coefficient effect) is due to changes in some variables that are not in the data. These include important parental indicators such as parents' heights and other health indicators, which are partly transmitted to children genetically.

6. SUMMARY AND CONCLUSIONS

Using data from the first and third round of NFHS, this paper made an attempt to analyse the drivers of change in nutritional outcomes of young girls in rural India. Previous work on child health has mainly focused on the change in average nutritional outcomes, but does not distinguish between undernourished and well-nourished children. We examine change across different quantiles of the nutrition status distribution. We use two anthropometric indicators, expressed in z-scores, to assess nutritional status: stunting as captured by height-for-age (HAZ) and underweight, as measured by weight-for–age (WAZ). Although our results show modest improvement in the anthropometric performance, girl-child undernutrition remains widespread in rural India. Broadly, we find that improvements show an uneven trend: declining with significantly greater improvement at the lower percentiles i.e. for stunted and underweight girls. We explore the reasons behind this trend in relation to various child, mother and household level correlates of the anthropometric outcomes using OLS and QR methods. The OLS and QR results suggest that there is a conspicuous decline in the returns to many of the factors influencing child undernutrition, and markedly more for the WAZ distribution. These include, more than primary education of the mother (relative to no education), having access to improved toilets (relative to poor or no toilets), and belonging to ST (relative to OBC and others caste) category. There is no factor to which the returns increased meaningfully between the two rounds.

In order to understand what is driving the change in the anthropometric outcomes, we perform the decomposition analysis. We decompose the change into its constituent components at the mean, using the OB method, and across the distribution using QR based MM method. We find for the HAZ measure, the results of OB and MM are in consonance with each other with coefficient effect contributing relatively more to the overall change than the covariate effect. The disaggregate OB of HAZ, however, reveals that bulk of the coefficient effect is coming from the intercept. The positive intercept term (picks up the effect of all other covariates not included in the model), while more difficult to interpret, suggests that the improvement in HAZ is likely to pick up the effect of policies and interventions related to food, nutrition and sanitation that were put in place years ago. Another important excluded covariate is mother's health which is related to child's height through the genetics pathway. We can argue that our sample of interviewed mothers in NFHS-3 are relatively healthier compared to those interviewed in NFHS-1. The NFHS-3 parents were by and large a part of post Green Revolution period and were less likely to be food insecure, whereas NFHS-1 parents were young children before the Green Revolution, and may have been both nutritionally deprived, and also, may have faced severe droughts. It is possible that this affected their heights more permanently than weights, and part of this is showing up in the positive intercept contribution in HAZ decomposition, but not in WAZ decomposition. Thus, the cohort of children born to NFHS-3 mothers are relatively taller which gets reflected in the positive and dominant contribution of the intercept to the coefficient effect.

Turning to the decomposition of the WAZ indicator, we find that it is the improvement in the covariates, mostly related to improved endowment of mother's education, number of vaccines received, improved toilets and household wealth that explains the improvement in the mean WAZ. The results are, however, enriched by MM decomposition which suggests that the coefficient effect is equally important for the bottom half of the distribution, that is, for the relatively undernourished.

An important finding of this analysis is that improvements have been higher for the most vulnerable girls and for them both the covariate and coefficient effects are important. We are also able to highlight the factors associated with poor nutrition as well as improved outcomes which can be targeted through specific interventions and policy initiatives: health and hygiene infrastructure; mother's education; and household's economic status. Therefore, efforts should be directed in designing and implementing policies targeting these factors such that both the covariate and coefficient effects work complementarily to each other in lowering and ultimately eradicating the problem of girl-child undernutrition in India.

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Appendix Tables

Table A1A: Mean and quantile regression estimates of HAZ of rural girls under four years, by NFHS round (state fixed effects)

Height-for-Age Z-score	**NFHS-1: 1992-3**						**NFHS-3: 2005-6**					
	Mean	**P10**	**P30**	**P50**	**P70**	**P90**	**Mean**	**P10**	**P30**	**P50**	**P70**	**P90**
Child Characteristics:												
Age	-0.12*** (0.01)	-0.11*** (0.01)	-0.12*** (0.01)	-0.13*** (0.01)	-0.13*** (0.01)	-0.14*** (0.01)	-0.11*** (0.01)	-0.07*** (0.01)	-0.11*** (0.01)	-0.13*** (0.01)	-0.14*** (0.01)	-0.14*** (0.01)
Age squared	0.17*** (0.01)	0.14*** (0.02)	0.16*** (0.01)	0.18*** (0.01)	0.18*** (0.01)	0.19*** (0.02)	0.17*** (0.01)	0.09*** (0.02)	0.16*** (0.01)	0.19*** (0.01)	0.21*** (0.01)	0.20*** (0.03)
Birth order 1	0.06 (0.05)	0.11 (0.07)	0.05 (0.05)	0.06 (0.05)	0.05 (0.06)	0.02 (0.10)	0.05 (0.05)	0.17** (0.08)	0.07 (0.06)	0.08 (0.05)	-0.04 (0.06)	-0.11 (0.11)
Birth order 2	0.00 (0.04)	0.05 (0.07)	-0.00 (0.05)	0.04 (0.05)	0.04 (0.06)	-0.03 (0.10)	0.05 (0.05)	0.11 (0.08)	0.01 (0.06)	0.03 (0.05)	-0.02 (0.06)	0.02 (0.11)
Vaccines	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00** (0.00)	-0.00 (0.00)	0.00 (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	-0.00 (0.00)	-0.00* (0.00)
Mother's Characteristics:												
Age at first birth	0.02*** (0.01)	0.01 (0.01)	0.02** (0.01)	0.03*** (0.01)	0.03*** (0.01)	0.02 (0.01)	0.01** (0.01)	0.01 (0.01)	0.02*** (0.01)	0.02*** (0.01)	0.02*** (0.01)	0.01 (0.01)
Education: Atmost pimary	0.10** (0.05)	0.20** (0.08)	0.18*** (0.06)	0.10* (0.06)	0.10 (0.07)	-0.04 (0.12)	0.09 (0.06)	0.23** (0.09)	0.09 (0.07)	0.05 (0.06)	0.03 (0.07)	-0.04 (0.13)
Education: Above primary	0.31*** (0.06)	0.33*** (0.09)	0.31*** (0.07)	0.31*** (0.07)	0.39*** (0.07)	0.25* (0.13)	0.24*** (0.06)	0.45*** (0.08)	0.28*** (0.06)	0.23*** (0.06)	0.22*** (0.07)	0.11 (0.12)
Household's Characteristics:												
Sanitation: Improved Water	0.12** (0.05)	-0.04 (0.07)	0.01 (0.05)	0.01 (0.05)	0.14** (0.06)	0.28*** (0.10)	-0.13** (0.06)	-0.11 (0.08)	-0.14** (0.06)	-0.15*** (0.05)	-0.19*** (0.06)	-0.14 (0.11)
Sanitation: Improved Toilet	0.03 (0.07)	-0.15 (0.10)	-0.04 (0.07)	0.02 (0.07)	0.06 (0.08)	0.16 (0.14)	-0.01 (0.07)	-0.07 (0.10)	0.01 (0.07)	0.01 (0.06)	-0.02 (0.08)	-0.00 (0.13)
Wealth Index	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.00** (0.00)	0.00 (0.00)	0.01*** (0.00)	0.02*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)
SC	-0.09 (0.07)	0.01 (0.08)	-0.07 (0.06)	-0.12* (0.06)	-0.08 (0.07)	-0.15 (0.12)	-0.09 (0.06)	-0.19** (0.08)	-0.11* (0.06)	-0.09 (0.06)	-0.10 (0.07)	-0.07 (0.12)
ST	0.17* (0.09)	0.04 (0.10)	0.18** (0.07)	0.15** (0.07)	0.13 (0.08)	0.12 (0.15)	0.06 (0.07)	0.01 (0.09)	-0.04 (0.07)	-0.02 (0.06)	0.04 (0.08)	0.03 (0.13)

HH Size	-0.01	-0.01*	-0.01**	-0.01**	-0.00	0.01	-0.01	-0.01	-0.01	-0.01**	-0.01	-0.01
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Punjab	-0.02	0.22	-0.12	-0.01	-0.00	0.13	-0.34*	-0.15	-0.11	-0.23	-0.39**	-0.95***
	(0.11)	(0.18)	(0.14)	(0.13)	(0.15)	(0.26)	(0.18)	(0.23)	(0.17)	(0.15)	(0.18)	(0.32)
Haryana	-0.24**	-0.11	-0.21	-0.12	-0.16	-0.18	-0.51***	-0.21	-0.30*	-0.43***	-0.63***	-1.16***
	(0.10)	(0.18)	(0.14)	(0.13)	(0.15)	(0.26)	(0.16)	(0.21)	(0.16)	(0.14)	(0.17)	(0.29)
Delhi	-0.36	-0.34	-0.55**	-0.10	-0.19	-0.25	-0.98***	-1.35**	-0.99**	-0.94**	-1.17***	-1.53**
	(0.24)	(0.34)	(0.25)	(0.25)	(0.29)	(0.50)	(0.20)	(0.55)	(0.42)	(0.37)	(0.44)	(0.77)

Table A1A contd. Height-for-Age Z-score	NFHS-1: 1992-3						NFHS-3: 2005-6					
	Mean	P10	P30	P50	P70	P90	Mean	P10	P30	P50	P70	P90
Uttar Pradesh	-0.54*** (0.09)	-0.50*** (0.15)	-0.67*** (0.11)	-0.42*** (0.11)	-0.42*** (0.12)	-0.41* (0.21)	-0.57*** (0.14)	-0.16 (0.17)	-0.44*** (0.13)	-0.50*** (0.11)	-0.62*** (0.13)	-1.22*** (0.23)
Bihar	-0.37*** (0.12)	-0.52*** (0.16)	-0.59*** (0.12)	-0.29** (0.12)	-0.31** (0.14)	0.09 (0.24)	-0.35** (0.15)	0.12 (0.18)	-0.25* (0.13)	-0.35*** (0.12)	-0.42*** (0.14)	-1.00*** (0.24)
Arunachal Pradesh	-0.35* (0.21)	-0.36 (0.27)	-0.53*** (0.20)	-0.23 (0.20)	-0.32 (0.23)	-0.23 (0.40)	0.11 (0.23)	0.20 (0.25)	0.03 (0.19)	0.04 (0.17)	0.03 (0.20)	0.08 (0.35)
Nagaland	0.34 (0.23)	0.36 (0.26)	0.20 (0.19)	0.39** (0.19)	0.46** (0.22)	0.74* (0.38)	0.01 (0.19)	0.24 (0.21)	0.05 (0.16)	0.05 (0.14)	-0.11 (0.17)	-0.26 (0.29)
Manipur	0.18 (0.18)	0.30 (0.26)	0.36* (0.19)	0.22 (0.19)	0.22 (0.21)	0.42 (0.37)	-0.02 (0.17)	0.28 (0.20)	0.08 (0.15)	-0.00 (0.14)	-0.12 (0.16)	-0.61** (0.29)
Mizoram	-0.30 (0.20)	0.33 (0.33)	-0.11 (0.25)	-0.24 (0.25)	-0.32 (0.28)	-0.41 (0.49)	-0.29 (0.23)	0.08 (0.27)	-0.25 (0.21)	-0.37** (0.18)	-0.57*** (0.22)	-0.59 (0.38)
Tripura	-0.29* (0.18)	-0.20 (0.28)	-0.23 (0.21)	-0.02 (0.21)	-0.21 (0.24)	-0.37 (0.41)	-0.03 (0.22)	0.07 (0.27)	-0.01 (0.20)	0.02 (0.18)	-0.11 (0.21)	-0.26 (0.37)
Meghalaya	-0.39 (0.29)	-1.20*** (0.27)	-1.38*** (0.20)	-0.28 (0.20)	0.21 (0.23)	1.05*** (0.40)	-0.12 (0.21)	-0.31 (0.24)	-0.07 (0.18)	-0.20 (0.16)	-0.06 (0.19)	0.05 (0.34)
Assam	-0.18 (0.13)	0.04 (0.19)	-0.18 (0.14)	-0.09 (0.14)	-0.13 (0.16)	-0.11 (0.28)	-0.23 (0.17)	0.19 (0.21)	-0.09 (0.16)	-0.10 (0.14)	-0.23 (0.16)	-0.77*** (0.29)
Orissa	0.06 (0.14)	-0.03 (0.18)	-0.12 (0.13)	0.04 (0.13)	0.17 (0.15)	0.40 (0.26)	-0.39** (0.16)	0.28 (0.19)	-0.22 (0.15)	-0.43*** (0.13)	-0.55*** (0.16)	-1.07*** (0.27)
Gujarat	-0.17 (0.12)	-0.13 (0.18)	-0.32** (0.13)	-0.11 (0.13)	-0.08 (0.15)	0.07 (0.26)	-0.65*** (0.16)	-0.18 (0.21)	-0.51*** (0.16)	-0.63*** (0.14)	-0.81*** (0.17)	-1.39*** (0.29)
Maharashtra	-0.31*** (0.11)	-0.14 (0.18)	-0.28** (0.14)	-0.16 (0.13)	-0.32** (0.15)	-0.55** (0.27)	-0.52*** (0.16)	-0.02 (0.21)	-0.42*** (0.16)	-0.57*** (0.14)	-0.61*** (0.17)	-1.03*** (0.29)
Karnataka	-0.23** (0.11)	0.06 (0.17)	-0.15 (0.13)	-0.11 (0.13)	-0.16 (0.14)	-0.27 (0.25)	-0.25 (0.18)	-0.05 (0.20)	-0.36** (0.15)	-0.39*** (0.14)	-0.32** (0.16)	-0.58** (0.28)
Goa	0.21* (0.12)	0.37* (0.21)	0.13 (0.16)	0.29* (0.15)	0.34* (0.17)	0.26 (0.30)	-0.20 (0.20)	0.22 (0.26)	-0.15 (0.20)	-0.22 (0.17)	-0.34* (0.21)	-0.77** (0.36)
Kerala	0.18 (0.13)	0.47** (0.19)	0.33** (0.14)	0.30** (0.14)	0.17 (0.16)	0.20 (0.27)	0.08 (0.17)	0.36 (0.23)	0.04 (0.18)	-0.05 (0.16)	-0.12 (0.19)	-0.42 (0.33)
Constant	-1.11*** (0.17)	-3.12*** (0.24)	-1.78*** (0.18)	-1.31*** (0.18)	-0.52** (0.20)	0.98*** (0.36)	-0.61*** (0.21)	-3.77*** (0.27)	-1.98*** (0.20)	-0.72*** (0.18)	0.45** (0.22)	2.70*** (0.38)
Observations	9489	9489	9489	9489	9489	9489	7598	7598	7598	7598	7598	7598
r2	0.19						0.16					

Source: Author estimates from NFHS-1 (1992-3) and NFHS-3 (2005-6)
Note: Base category is rural Jammu & Kashmir girl of birth order 3 or more born to an illiterate mother, who was married in an OBC or other category household having poor drinking water and toilet facility. Robust standard errors clustered at the PSU level are reported in parentheses for OLS. QR standard errors in parentheses are bootstrapped using 200 replications; ***, ** and * indicate significance at 1, 5, and 10 percent respectively

Table A1B: Mean and quantile regression estimates of WAZ of rural girls under four years, by NFHS round (state fixed effects)

Weight-for-Age Z-score	**NFHS-1: 1992-3**						**NFHS-3: 2005-6**					
	Mean	**P10**	**P30**	**P50**	**P70**	**P90**	**Mean**	**P10**	**P30**	**P50**	**P70**	**P90**
Child Characteristics:												
Age	-0.06***	-0.06***	-0.06***	-0.06***	-0.05***	-0.06***	-0.04***	-0.04***	-0.04***	-0.04***	-0.04***	-0.05***
	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Age squared	0.08***	0.09***	0.08***	0.08***	0.07***	0.07***	0.05***	0.06***	0.05***	0.05***	0.05***	0.06***
	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
Birth order 1	0.06	0.07	0.08*	0.05	0.03	-0.02	0.09**	0.20***	0.10**	0.11**	0.04	-0.02
	(0.04)	(0.07)	(0.04)	(0.04)	(0.05)	(0.06)	(0.04)	(0.08)	(0.05)	(0.05)	(0.04)	(0.07)
Birth order 2	0.01	0.04	0.04	0.00	-0.00	-0.02	0.04	0.14*	0.04	0.03	0.01	-0.05
	(0.04)	(0.07)	(0.04)	(0.04)	(0.05)	(0.06)	(0.04)	(0.08)	(0.05)	(0.05)	(0.04)	(0.07)
Vaccines	0.00***	0.00***	0.00***	0.00***	0.00	0.00	0.00***	0.00***	0.00***	0.00***	0.00*	-0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Mother's Characteristics:												
Age at first birth	0.01***	0.02**	0.01**	0.01**	0.02***	0.02***	0.01	0.00	0.01	0.02***	0.01***	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Education: At most primary	0.10**	0.18**	0.11**	0.09*	0.10*	0.06	0.02	-0.07	0.04	0.03	0.01	-0.01
	(0.05)	(0.08)	(0.05)	(0.05)	(0.05)	(0.07)	(0.05)	(0.09)	(0.06)	(0.06)	(0.05)	(0.08)
Education: Above primary	0.34***	0.42***	0.32***	0.35***	0.38***	0.35***	0.18***	0.23***	0.20***	0.15***	0.18***	0.17**
	(0.05)	(0.09)	(0.06)	(0.06)	(0.06)	(0.08)	(0.04)	(0.08)	(0.05)	(0.05)	(0.05)	(0.07)
Household's Characteristics:												
Sanitation: Improved Water	0.04	-0.03	-0.06	0.00	0.09*	0.14**	-0.08*	-0.13*	-0.04	-0.06	-0.10**	-0.18***
	(0.04)	(0.07)	(0.04)	(0.04)	(0.04)	(0.06)	(0.04)	(0.07)	(0.05)	(0.05)	(0.04)	(0.07)
Sanitation: Improved Toilet	0.07	0.01	0.11*	0.12*	0.10	0.01	-0.03	0.09	0.03	-0.03	-0.05	-0.13*
	(0.06)	(0.10)	(0.06)	(0.06)	(0.07)	(0.09)	(0.05)	(0.09)	(0.06)	(0.06)	(0.06)	(0.08)
Wealth Index	0.01***	0.01***	0.01***	0.01***	0.00**	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

SC	-0.16*** (0.05)	-0.19** (0.08)	-0.15*** (0.05)	-0.14*** (0.05)	-0.14** (0.06)	-0.19*** (0.07)	-0.14*** (0.04)	-0.21*** (0.08)	-0.18*** (0.05)	-0.13** (0.05)	-0.11** (0.05)	-0.11 (0.07)
ST	0.05 (0.07)	-0.08 (0.10)	0.07 (0.07)	0.08 (0.06)	0.08 (0.07)	0.00 (0.09)	-0.02 (0.05)	-0.13 (0.09)	-0.04 (0.06)	-0.04 (0.06)	0.01 (0.05)	0.01 (0.08)
HH Size	-0.01 (0.00)	-0.02*** (0.01)	-0.01** (0.00)	-0.00 (0.00)	0.00 (0.00)	-0.00 (0.01)	-0.01 (0.00)	0.00 (0.01)	-0.01 (0.01)	-0.01** (0.01)	-0.01 (0.01)	-0.01 (0.01)
Punjab	-0.15* (0.08)	0.07 (0.18)	-0.14 (0.12)	-0.12 (0.12)	-0.16 (0.13)	-0.33** (0.16)	-0.29** (0.13)	-0.42* (0.22)	-0.27* (0.15)	-0.18 (0.14)	-0.14 (0.13)	-0.36* (0.20)
Haryana	0.19** (0.08)	0.49*** (0.18)	0.30** (0.12)	0.20* (0.11)	0.20 (0.13)	-0.06 (0.16)	-0.60*** (0.11)	-0.55*** (0.21)	-0.54*** (0.14)	-0.55*** (0.13)	-0.60*** (0.12)	-0.77*** (0.18)
Delhi	-0.36* (0.20)	-0.13 (0.34)	-0.25 (0.22)	-0.28 (0.21)	-0.35 (0.23)	-0.29 (0.30)	-0.70*** (0.15)	-0.97* (0.54)	-0.75** (0.36)	-0.51 (0.35)	-0.45 (0.32)	-1.08** (0.48)
Rajasthan	0.82*** (0.15)	0.06 (0.17)	0.19* (0.11)	0.54*** (0.10)	1.23*** (0.11)	2.29*** (0.15)	-0.42*** (0.11)	-0.51*** (0.19)	-0.26** (0.12)	-0.27** (0.12)	-0.38*** (0.11)	-0.63*** (0.16)
Uttar Pradesh	-0.28*** (0.07)	-0.29** (0.15)	-0.32*** (0.10)	-0.26*** (0.09)	-0.21** (0.10)	-0.27** (0.13)	-0.48*** (0.10)	-0.48*** (0.16)	-0.33*** (0.11)	-0.40*** (0.10)	-0.50*** (0.10)	-0.58*** (0.14)

Table A1B contd. Weight-for-Age Z-score	NFHS-1: 1992-3						NFHS-3: 2005-6					
	Mean	**P10**	**P30**	**P50**	**P70**	**P90**	**Mean**	**P10**	**P30**	**P50**	**P70**	**P90**
Bihar	0.38**	0.40	0.30*	0.43***	0.30*	0.40*	0.04	-0.29	-0.04	0.07	0.19	0.12
	(0.16)	(0.27)	(0.17)	(0.17)	(0.18)	(0.24)	(0.16)	(0.24)	(0.16)	(0.16)	(0.14)	(0.21)
Arunachal Pradesh	0.75***	0.90***	0.74***	0.51***	0.68***	0.91***	0.17	0.27	0.28**	0.19	0.15	-0.01
	(0.17)	(0.26)	(0.17)	(0.16)	(0.18)	(0.23)	(0.13)	(0.20)	(0.14)	(0.13)	(0.12)	(0.18)
Nagaland	0.62***	0.88***	0.58***	0.50***	0.53***	0.51**	0.12	0.24	0.24*	0.09	0.03	-0.11
	(0.15)	(0.26)	(0.17)	(0.16)	(0.18)	(0.23)	(0.11)	(0.20)	(0.13)	(0.13)	(0.12)	(0.18)
Manipur	0.46**	0.69**	0.30	0.25	0.54**	0.54*	0.05	0.39	0.20	0.00	-0.13	-0.28
	(0.18)	(0.34)	(0.22)	(0.21)	(0.23)	(0.30)	(0.14)	(0.27)	(0.18)	(0.17)	(0.16)	(0.23)
Mizoram	-0.12	-0.10	0.03	0.00	-0.17	-0.32	-0.38**	-1.02***	-0.38**	-0.18	-0.20	-0.30
	(0.15)	(0.27)	(0.18)	(0.17)	(0.18)	(0.24)	(0.18)	(0.26)	(0.17)	(0.17)	(0.15)	(0.23)
Tripura	0.32	-0.20	0.02	0.32*	0.68***	1.08***	-1.02***	-1.60***	-1.02***	-0.78***	-0.74***	-0.81***
	(0.21)	(0.26)	(0.17)	(0.16)	(0.18)	(0.23)	(0.18)	(0.24)	(0.16)	(0.15)	(0.14)	(0.21)
Meghalaya	0.02	0.36*	0.08	0.02	-0.01	-0.14	-0.24**	-0.12	-0.15	-0.22*	-0.25**	-0.32*
	(0.10)	(0.19)	(0.13)	(0.12)	(0.13)	(0.17)	(0.12)	(0.20)	(0.13)	(0.13)	(0.12)	(0.18)
Assam	0.10	0.04	-0.08	-0.00	0.11	0.46***	-0.41***	-0.22	-0.22*	-0.44***	-0.46***	-0.71***
	(0.11)	(0.18)	(0.12)	(0.11)	(0.12)	(0.16)	(0.11)	(0.19)	(0.13)	(0.12)	(0.11)	(0.17)
Orissa	-0.21**	0.03	-0.20*	-0.17	-0.25**	-0.33**	-0.69***	-0.82***	-0.52***	-0.58***	-0.64***	-0.86***
	(0.08)	(0.18)	(0.12)	(0.11)	(0.12)	(0.16)	(0.12)	(0.21)	(0.14)	(0.13)	(0.12)	(0.18)
Gujarat	-0.33***	-0.27	-0.39***	-0.38***	-0.34***	-0.39**	-0.62***	-0.55***	-0.52***	-0.63***	-0.59***	-0.79***
	(0.10)	(0.19)	(0.12)	(0.12)	(0.13)	(0.16)	(0.11)	(0.20)	(0.14)	(0.13)	(0.12)	(0.18)
Maharashtra	-0.22**	-0.12	-0.16	-0.19*	-0.24**	-0.32**	-0.40***	-0.48**	-0.37***	-0.39***	-0.36***	-0.42**
	(0.09)	(0.17)	(0.11)	(0.11)	(0.12)	(0.16)	(0.12)	(0.20)	(0.13)	(0.13)	(0.12)	(0.17)
Karnataka	0.21*	0.31	0.17	0.21	0.21	0.21	-0.38***	-0.47*	-0.46***	-0.43***	-0.23	-0.46**
	(0.11)	(0.21)	(0.14)	(0.13)	(0.14)	(0.19)	(0.14)	(0.26)	(0.17)	(0.16)	(0.15)	(0.22)
Goa	0.23**	0.46**	0.24*	0.24**	0.16	0.01	-0.32***	-0.39*	-0.24	-0.29**	-0.39***	-0.38*
	(0.10)	(0.19)	(0.12)	(0.12)	(0.13)	(0.17)	(0.12)	(0.23)	(0.15)	(0.15)	(0.14)	(0.20)
Kerala	-1.71***	-3.68***	-2.34***	-1.68***	-1.22***	-0.20	-1.34***	-3.20***	-2.20***	-1.44***	-0.65***	0.82***
	(0.14)	(0.24)	(0.16)	(0.15)	(0.17)	(0.22)	(0.15)	(0.26)	(0.17)	(0.17)	(0.16)	(0.23)
Observations	9794	9794	9794	9794	9794	9794	7787	7787	7787	7787	7787	7787

r2	0.13	0.15

Source: Author estimates from NFHS-1 (1992-3) and NFHS-3 (2005-6)
Note: Base category is rural Jammu & Kashmir girl of birth order 3 or more born to an illiterate mother, who was married in an OBC or other category household having poor drinking water and toilet facility. Robust standard errors clustered at the PSU level are reported in parentheses for OLS. QR standard errors in parentheses are bootstrapped using 200 replications; ***, ** and * indicate significance at 1, 5, and 10 percent respectively

Table A2: Change[a] in mean and quantile regression estimates of anthropometric outcomes of rural girls between 1992/93 and 2005/06 (state fixed effects)

	Change in Height-for-Age Z-scores						Change in Weight-for-Age Z-scores					
	Mean	**P10**	**P30**	**P50**	**P70**	**P90**	**Mean**	**P10**	**P30**	**P50**	**P70**	**P90**
Child Characteristics:												
Age	0.01 (0.01)	0.03*** (0.01)	0.02* (0.01)	0.004 (0.01)	-0.004 (0.01)	0.004 (0.02)	0.02** (0.01)	0.02 (0.01)	0.02** (0.01)	0.02** (0.01)	0.01 (0.01)	0.01 (0.01)
Age squared	0.000 (0.02)	-0.04** (0.02)	-0.01 (0.02)	0.01 (0.02)	0.03 (0.02)	0.001 (0.04)	-0.03** (0.01)	-0.03 (0.03)	-0.03 (0.02)	-0.02 (0.02)	-0.01 (0.01)	-0.02 (0.02)
Birth order 1	-0.01 (0.07)	0.07 (0.11)	0.05 (0.08)	0.02 (0.07)	-0.06 (0.08)	-0.14 (0.15)	0.04 (0.06)	0.13 (0.10)	0.03 (0.07)	0.05 (0.07)	0.01 (0.07)	-0.02 (0.09)
Birth order 2	0.04 (0.07)	0.09 (0.11)	0.03 (0.08)	0.01 (0.07)	-0.04 (0.08)	0.004 (0.15)	0.02 (0.05)	0.08 (0.10)	0.01 (0.07)	0.03 (0.06)	0.02 (0.07)	-0.003 (0.09)
Vaccines	-0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	-0.001** (0.001)	-0.003* (0.002)	0.000 (0.001)	0.001 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)
Mother's Characteristics:												
Age at first birth	-0.01 (0.01)	-0.001 (0.01)	0.003 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.02)	-0.01 (0.01)	-0.02 (0.01)	-0.002 (0.01)	0.001 (0.01)	-0.01 (0.01)	-0.02 (0.01)
Education: At most primary	-0.01 (0.08)	-0.001 (0.12)	-0.07 (0.08)	-0.05 (0.08)	-0.06 (0.08)	0.05 (0.18)	-0.08 (0.06)	-0.23* (0.14)	-0.07 (0.08)	-0.05 (0.07)	-0.22 (0.07)	-0.08 (0.09)
Education: Above primary	-0.06 (0.08)	0.13 (0.14)	-0.04 (0.10)	-0.08 (0.08)	-0.17* (0.09)	-0.13 (0.16)	-0.17** (0.06)	-0.16 (0.12)	-0.13* (0.08)	-0.19*** (0.07)	-0.18*** (0.07)	-0.17* (0.10)
Household's Characteristics:												
Sanitation: Improved Water	-0.25*** (0.07)	-0.06 (0.11)	-0.15* (0.08)	-0.15** (0.07)	-0.32*** (0.08)	-0.41*** (0.14)	-0.13** (0.06)	-0.08 (0.11)	0.02 (0.07)	-0.06 (0.07)	-0.18** (0.07)	-0.29*** (0.09)
Sanitation: Improved Toilet	-0.05 (0.09)	0.07 (0.14)	0.05 (0.11)	-0.02 (0.09)	-0.06 (0.10)	-0.22 (0.19)	-0.09 (0.07)	-0.01 (0.13)	-0.10 (0.08)	-0.15** (0.07)	-0.16** (0.08)	-0.16 (0.12)
Wealth Index	0.004** (0.002)	0.004 (0.004)	0.001 (0.002)	0.004* (0.002)	0.007*** (0.002)	0.009** (0.004)	0.01*** (0.001)	0.002 (0.003)	0.003 (0.001)	0.004** (0.002)	0.007*** (0.002)	0.009*** (0.003)

SC	0.000 (0.08)	-0.17 (0.11)	-0.02 (0.19)	0.05 (0.09)	-0.003 (0.10)	0.10 (0.17)	0.02 (0.06)	-0.07 (0.12)	-0.02 (0.07)	-0.001 (0.08)	0.02 (0.06)	0.11 (0.10)
ST	-0.10 (0.10)	-0.06 (0.15)	-0.17 (0.11)	-0.14 (0.10)	-0.06 (0.11)	-0.000 (0.23)	-0.07 (0.09)	-0.04 (0.15)	-0.10 (0.11)	-0.10 (0.09)	-0.08 (0.10)	0.04 (0.14)
HH Size	-0.000 (0.01)	0.01 (0.01)	0.002 (0.01)	-0.002 (0.01)	-0.01 (0.01)	-0.02 (0.02)	-0.000 (0.01)	0.02 (0.01)	0.004 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Punjab	-0.32* (0.18)	-0.38 (0.28)	0.004 (0.20)	-0.18 (0.21)	-0.35 (0.22)	-0.88*** (0.32)	-0.12 (0.14)	-0.39 (0.30)	-0.09 (0.19)	-0.11 (0.17)	0.00 (0.19)	-0.11 (0.22)
Haryana	-0.25 (0.17)	-0.17 (0.32)	-0.07 (0.18)	-0.28 (0.20)	-0.47*** (0.18)	-0.83** (0.40)	-0.79*** (0.13)	-0.99*** (0.28)	-0.82*** (0.19)	-0.77*** (0.16)	-0.81*** (0.17)	-0.76*** (0.23)
Delhi	-0.62 (0.48)	-0.96 (0.70)	-0.46 (0.59)	-0.82* (0.49)	-0.86* (0.49)	-0.77 (1.44)	-0.33 (0.32)	-0.76 (0.55)	-0.53 (0.65)	-0.23 (0.43)	-0.13 (0.32)	-0.43 (0.91)

Table A2 contd.	**Change in Height-for-Age Z-scores**						**Change in Weight-for-Age Z-scores**					
	Mean	**P10**	**P30**	**P50**	**P70**	**P90**	**Mean**	**P10**	**P30**	**P50**	**P70**	**P90**
Rajasthan	-0.96*** (0.19)	0.37 (0.31)	-0.14 (0.19)	-0.52** (0.24)	-1.36*** (0.27)	-3.61*** (0.39)	-1.25** (0.15)	-0.49 (0.30)	-0.44** (0.19)	-0.85*** (0.18)	1.62*** (0.20)	-2.98*** (0.24)
Uttar Pradesh	-0.03 (0.15)	-0.26 (0.23)	0.24 (0.15)	-0.03 (0.18)	-0.19 (0.17)	-0.67** (0.27)	-0.20 (0.11)	-0.14 (0.24)	-0.02 (0.17)	-0.18 (0.12)	-0.30* (0.13)	-0.32* (0.19)
Bihar	0.02** (0.16)	0.59** (0.23)	0.34** (0.16)	0.001 (0.19)	-0.11 (0.18)	-0.94*** (0.31)	-0.53* (0.13)	-0.32 (0.26)	-0.24 (0.18)	-0.46*** (0.14)	-0.61*** (0.15)	-0.91*** (0.21)
Arunachal Pradesh	0.47* (0.26)	0.66** (0.39)	0.54* (0.31)	0.34 (0.25)	0.32 (0.38)	0.14 (0.56)	0.35* (0.20)	0.56 (0.41)	-0.29 (0.25)	0.44* (0.25)	-0.11 (0.24)	-0.32* (0.35)
Nagaland	-0.31 (0.21)	-0.15 (0.40)	-0.20 (0.24)	-0.31 (0.25)	-0.62* (0.33)	-0.94* (0.56)	-0.58 (0.19)	-0.61* (0.33)	-0.43** (0.23)	-0.38* (0.22)	-0.53* (0.25)	-0.90*** (0.36)
Manipur	0.17 (0.23)	0.01 (0.48)	-0.24 (0.28)	-0.15 (0.23)	-0.30 (0.27)	-0.81* (0.46)	-0.51 (0.16)	-0.55** (0.28)	-0.36 (0.22)	-0.47*** (0.19)	-0.49* (0.20)	-0.68*** (0.27)
Mizoram	0.004 (0.27)	-0.23 (0.52)	-0.17 (0.27)	-0.11 (0.27)	-0.22 (0.35)	-0.02 (0.52)	-0.40 (0.18)	-0.27 (0.37)	-0.15 (0.26)	-0.33 (0.22)	-0.60** (0.26)	-0.80** (0.38)
Tripura	0.28 (0.25)	0.31 (0.41)	0.23 (0.30)	0.14 (0.30)	0.13 (0.27)	0.20 (0.37)	-0.26 (0.20)	-0.84 (0.51)	-0.33 (0.26)	0.19 (0.20)	-0.03 (0.21)	0.01 (0.33)
Meghalaya	0.27 (0.30)	0.99** (0.39)	1.21** (0.36)	0.28 (0.40)	-0.33 (0.40)	-1.02 (0.63)	-1.34 (0.21)	-1.35*** (0.35)	-1.02*** (0.37)	-1.17*** (0.26)	-1.41*** (0.34)	-1.92** (0.40)
Assam	-0.04 (0.18)	0.10 (0.28)	0.09 (0.21)	0.05 (0.21)	-0.11 (0.23)	-0.52 (0.33)	-0.25 (0.15)	-0.38 (0.32)	-0.21 (0.21)	-0.28 (0.18)	-0.24 (0.16)	-0.24 (0.24)
Orissa	-0.43*** (0.17)	0.21 (0.24)	-0.10 (0.17)	-0.42** (0.20)	-0.69*** (0.22)	-1.40*** (0.35)	-0.52*** (0.14)	-0.26 (0.27)	-0.17 (0.19)	-0.44** (0.16)	-0.56*** (0.17)	-1.07*** (0.26)
Gujarat	-0.47*** (0.16)	-0.11 (0.30)	-0.17 (0.17)	-0.46** (0.19)	-0.70*** (0.18)	-1.31*** (0.33)	-0.47*** (0.12)	-0.74 (0.30)	-0.32* (0.18)	-0.42*** (0.15)	-0.42*** (0.16)	-0.56*** (0.22)
Maharashtra	-0.20 (0.19)	0.06 (0.26)	-0.16 (0.19)	-0.36* (0.20)	-0.30 (0.23)	-0.38** (0.41)	-0.28 (0.14)	0.27 (0.29)	-0.17 (0.20)	-0.28* (0.17)	-0.27* (0.16)	-0.37* (0.22)
Karnataka	0.01 (0.17)	-0.17 (0.23)	-0.20 (0.18)	-0.18 (0.21)	-0.16 (0.19)	-0.02 (0.39)	-0.17 (0.13)	-0.33 (0.28)	-0.24 (0.18)	-0.26* (0.14)	-0.15 (0.15)	-0.12 (0.22)
Goa	-0.39** (0.20)	-0.15 (0.30)	-0.20 (0.25)	-0.46** (0.23)	-0.57** (0.23)	-0.90** (0.36)	-0.61*** (0.15)	-0.70** (0.28)	-0.62*** (0.24)	-0.64*** (0.21)	-0.49** (0.20)	-0.71*** (0.30)
Kerala	-0.09 (0.17)	-0.12 (0.30)	-0.26 (0.20)	-0.27** (0.21)	-0.29 (0.21)	-0.46 (0.34)	-0.54*** (0.14)	-0.75** (0.29)	-0.50** (0.20)	-0.54*** (0.15)	-0.55*** (0.16)	-0.48* (0.27)
Constant	0.48* (0.26)	-0.57 (0.37)	-0.18 (0.27)	0.52* (0.28)	1.01*** (0.28)	1.65*** (0.52)	0.36**** (0.19)	-0.39 (0.41)	0.11 (0.25)	0.30* (0.22)	0.56** (0.26)	0.88** (0.35)
Observations	9489	9489	9489	9489	9489	9489	7598	7598	7598	7598	7598	7598

Source: Author estimates from NFHS-1 (1992-3) and NFHS-3 (2005-6)
Note: Base category is rural Jammu & Kashmir girl of birth order 3 or more born to an illiterate mother, who was married in an OBC or other category household having poor drinking water and toilet facility. Robust standard errors clustered at the PSU level are reported in parentheses for OLS. QR standard errors in parentheses are bootstrapped using 200 replications; ***, ** and * indicate significance at 1, 5, and 10 percent respectively

Table A3: The aggregate Oaxaca-Blinder decomposition using 1992/93 coefficients to create the counterfactual

	Change in Height-for-Age Z-scores		Change in Weight-for-Age Z-scores	
	Estimate	**% of Total Change**	**Estimate**	**% of Total Change**
Covariate Effect	0.13*** (0.02)	36	0.15*** (0.02)	109
Coefficient Effect	0.23*** (0.04)	64	-0.01 (0.02)	-9
Total Change[a]	0.36*** (0.03)		0.14*** (0.03)	
Observations	17087		17581	

Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)
Notes: Change is calculated as [Estimates in 2005/06 - Estimates in 1992/93].
The data refer to young girls under four years of age. Robust standard errors clustered at the PSU level are reported in parentheses. ***, ** and * indicate significance at 1, 5, and 10 percent, respectively.

Table A4: The Machado-Mata decomposition using 1992/93 coefficients to create the counterfactual distribution

	Change in Height-for-Age Z-score					Change in Weight-for-Age Z-score				
		Covariate Effect		Coefficient Effect			Covariate Effect		Coefficient Effect	
Percentile	**Total Change[a]**	**Estimate**	**% of Total Change**	**Estimate**	**% of Total Change**	**Total Change**	**Estimate**	**% of Total Change**	**Estimate**	**% of Total Change**
10	0.57***	0.17***	30	0.41***	70	0.30***	0.19***	65	0.11**	35
	(0.06)	(0.06)		(0.06)		(0.06)	(0.06)		(0.06)	
20	0.51***	0.17***	32	0.35***	68	0.27***	0.18***	68	0.09**	32
	(0.05)	(0.05)		(0.05)		(0.04)	(0.04)		(0.04)	
30	0.43***	0.16***	36	0.29***	64	0.24***	0.17***	72	0.07**	28
	(0.04)	(0.05)		(0.04)		(0.04)	(0.04)		(0.04)	
40	0.38***	0.15***	40	0.23***	60	0.21***	0.17***	80	0.04	20
	(0.04)	(0.04)		(0.04)		(0.04)	(0.04)		(0.03)	
50	0.35***	0.15***	44	0.20***	56	0.17***	0.16***	93	0.01	7
	(0.04)	(0.04)		(0.04)		(0.03)	(0.04)		(0.03)	
60	0.32***	0.15***	47	0.17***	53	0.14***	0.16***	108	-0.01	-8
	(0.05)	(0.04)		(0.04)		(0.03)	(0.03)		(0.03)	
70	0.29***	0.14***	49	0.15***	51	0.12***	0.15***	130	-0.03	-30
	(0.05)	(0.05)		(0.04)		(0.03)	(0.04)		(0.03)	
80	0.28***	0.12**	43	0.16***	57	0.08**	0.14***	179	-0.06	-68
	(0.05)	(0.05)		(0.06)		(0.04)	(0.04)		(0.04)	

90	0.29***	0.09	31	0.20**	69	-0.01	0.09**	1488	-0.10*	-1588
	(0.7)	(0.08)		(0.07)		(0.05)	(0.05)		(0.05)	

Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)
Notes: a- Change is calculated as [Estimates in 2005/06 - Estimates in 1992/93].
The data refer to young girls under four years of age. Standard errors in parentheses are bootstrapped using 200 replications; ***, ** and * indicate significance at 1, 5, and 10 percent, respectively.

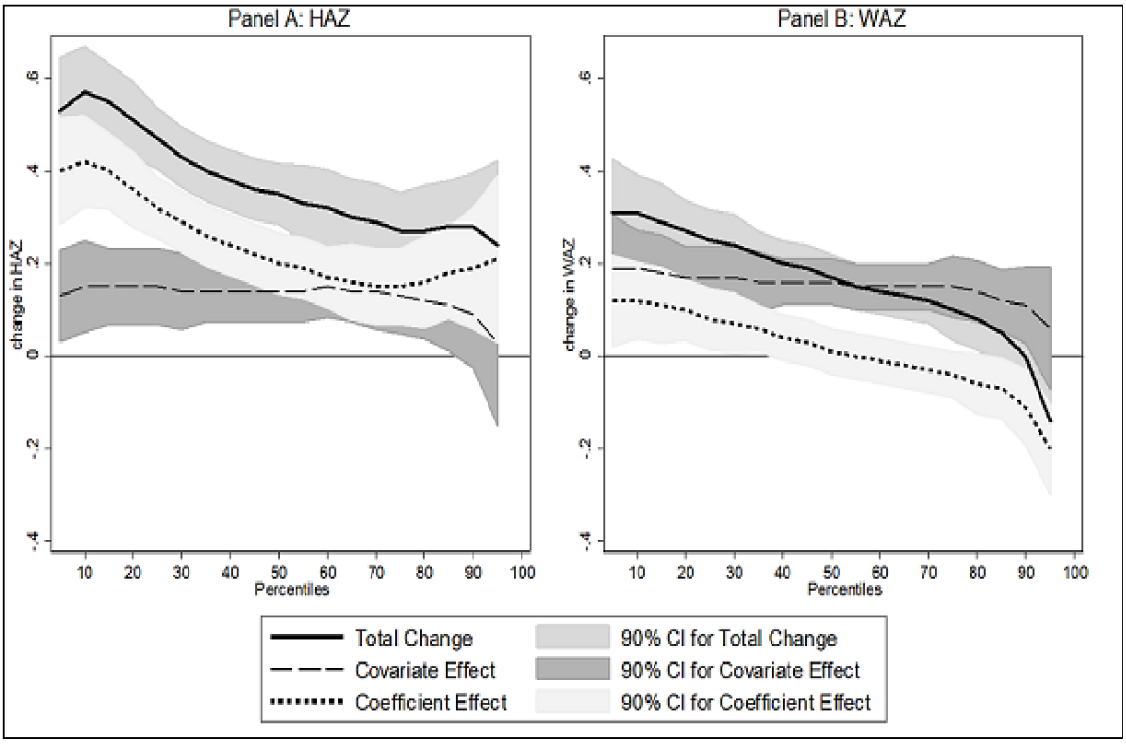
Table A5: The disaggregate Oaxaca-Blinder decomposition using 1992/93 coefficients to create the counterfactual

	Change in Height-for-Age Z-scores				Change in Weight-for-Age Z-scores			
	Covariate Effect		**Coefficient Effect**		**Covariate Effect**		**Coefficient Effect**	
	Estimate	% of Total Change	Estimate	% of Total Change	Estimate	% of Total Change	Estimate	% of Total Change
Child Characteristics:								
Age	-0.04*** (0.01)	-12	0.18** (0.09)	51	-0.01*** (0.00)	-11	0.16** (0.07)	118
Birth order	0.00 (0.00)	1	-0.00 (0.03)	-1	0.00 (0.00)	2	-0.01 (0.02)	-7
Vaccines	0.04*** (0.01)	9	-0.09 (0.06)	-25	0.02* (0.01)	13	-0.00 (0.04)	-1
Mother Characteristics:								
Age at first birth	0.02*** (0.00)	6	-0.25 (0.17)	-67	0.02*** (0.00)	13	-0.18 (0.14)	-135
Education	0.06*** (0.01)	15	-0.04 (0.04)	-10	0.06*** (0.01)	44	-0.06** (0.03)	-42
Household Characteristics:								
Improved drinking water	0.00 (0.00)	0	-0.21*** (0.05)	-57	-0.00 (0.00)	-2	-0.09** (0.04)	-67
Improved toilet	0.01 (0.01)	2	0.01 (0.03)	2	0.02*** (0.01)	17	-0.04* (0.02)	-29
Wealth Index	0.02*** (0.01)	5	0.12* (0.06)	32	0.02*** (0.01)	11	0.17*** (0.05)	122
SC/ST	0.02*** (0.01)	6	-0.04 (0.03)	-11	0.02*** (0.01)	16	-0.07*** (0.02)	-49
HH Size	0.01** (0.01)	3	0.01 (0.05)	2	0.01* (0.00)	6	-0.02 (0.05)	-17
Constant			0.54*** (0.20)	149			0.13 (0.16)	99
Total Change[a]	0.13*** (0.02)	36	0.23*** (0.04)	64	0.15*** (0.02)	109	-0.01 (0.02)	-9
Observations	17087				17581			

Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)
Notes: a- Change is calculated as [Estimates in 2005/06 - Estimates in 1992/93].
The data refer to young girls under four years of age. Robust standard errors clustered at the PSU level are reported in parentheses; ***, ** and * indicate significance at 1, 5, and 10 percent, respectively.

Appendix Figures

Figure A1: The Machado-Mata decomposition using 1992/93 coefficients to create the counterfactual distribution



Source: Author's estimates from NFHS-1 (1992/93) and NFHS-3 (2005/06)
Notes: The data refer to young girls under four years of age. The 90 percent confidence band are obtained using the bootstrap technique (200 replications).