

Child Height in India

Facts and Interpretations from the NFHS-4, 2015–16

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An analysis of child height-for-age using the newly released data from the National Family Health Survey-4 indicates that the average child height increased by about four-tenths of a height-for-age standard deviation between 2005 and 2015. Although important, this increase is small relative to India's overall height deficit, and relative to economic progress; children in India remain among the shortest in the world. It is unsurprising that the increase in height-for-age has been modest because none of the principal factors responsible for India's poor child height outcomes have substantially improved over the last decade. Familiar patterns of regional, sex, and caste disadvantage are reflected in child height in 2015.

The average height of a population's children is increasingly recognised as an important measure of human development. This is because the distribution of height in a population is shaped by the health and well-being that children experience at young ages. Early life is an important time: what happens to babies and children matters for their achievement, health, and survival throughout their lives. So, when child height in a population is shorter than would be healthy and achievable, such a height deficit reflects a substantial measure of forgone well-being, both for the welfare of the present day and for the duration of the future time that stunted children will live and will influence the economy and society as adults.

As has been widely recognised, children in India are unhealthily short, on average. The average child in India is shorter than children raised by upper-middle-class families in Delhi; is shorter than children in other developing countries; and is much shorter than would be achievable with better health, nutrition, sanitation, and maternal well-being.

Although several sources of data have helped establish these facts, the National Family Health Survey (NFHS), which is India's Demographic and Health Survey (DHS), has been especially important for researchers' and policymakers' understanding of child height and health. Until January 2018, the most recent publicly available DHS for India was the 2005–06 round of the NFHS-3 (IPS and Macro International 2007). The purpose of this paper is to update our understanding of the facts of child height in India, using the newly released data. We analyse the fourth round of the NFHS-4, collected across India in 2015 and 2016 (IPS and ICF 2017). As part of the international DHS project, the NFHS-4 is a high-quality representative data set that is readily comparable to DHS from other developing and middle-income countries around the world.

The NFHS-4 data shows that the average child in India was about four-tenths of a height-for-age standard deviation taller in 2015–16 than in 2005–06. This improvement is about as large as the average gap between Dalit children and general caste children, a gap which did not close over time. Because Indian children were too short in 2005–06, this increase is an important improvement. But, average child height has been improving in other developing countries, too, so India (and especially its large, disadvantaged northern plains states) remains near, or at the bottom of the international ranking. Further, this improvement appears small compared with India's rapid economic progress, and the large remaining difference

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between the average Indian child and the heights attained by healthy children in India and around the world.

This paper documents and interprets patterns of child height using data from the NFHS-4. Section 1 summarises basic facts from the NFHS-4 about how tall children were in 2015–16 and how much improvement has occurred since 2005. Section 2 breaks these averages down by demographic group: child's sex and caste or tribe. Section 3 quantifies the pace of improvement and compares India with other developing countries. Section 4 observes that the main determinants of average height help explain why change has been slow: neither the maternal nutrition, nor sanitation and disease, nor breastfeeding practices showed a radical improvement over the decade between the NFHS-3 and the NFHS-4.

1 Quantifying Children's Height-for-age

The NFHS-4 measured the heights of 1,80,867 children all across India, who were less than five years old at the time they were surveyed. Clubbing together all of these children, their average height is about 83 centimetres. That number is not particularly informative, however, because it averages over newborns and 59-month-olds, who, by virtue of their different ages, have very different dimensions.

To consider average height among children at different ages, researchers use an indicator called "height-for-age." A child's height-for-age is a measure of their height, relative to a healthy standard population of the same sex and the same age-in-months. These standards were developed by the World Health Organization (WHO 2006) by studying healthy children, including a large group of healthy children living in south Delhi (Bhandari et al 2002). Experts across disciplines agree that these standards apply to Indian children.¹

Height-for-age is measured using *z*-scores, meaning that it is expressed as a difference between the height of the observed child and the average height of healthy children, scaled by the standard deviation of child height in the healthy population. A child with a height-for-age *z*-score of zero would be as tall as the average child in the healthy reference population; a child with a negative height-for-age *z*-score is shorter than the average child in the healthy reference population.

Table 1 uses NFHS-4 data to show that the average height-for-age *z*-score among Indian children in 2015–16 was -1.48. The fact that the number is negative indicates that the average child in India is shorter than the average child in a healthy population. In fact, in a healthy population, only about 7% of children would be as short, or shorter than the average Indian child.

In Sections 1.1, 1.2, and 1.3, we use height-for-age *z*-scores to explore how children's height and health have changed during the last decade. Section 1.1 finds that the average child in India was four-tenths of a height-for-age standard deviation taller in 2015–16 than the average child in India was in 2005–06. However, the average child in India is still unhealthily short. Section 1.2 shows that height-for-age is related to a child's age and explains what this important relationship can tell us about how to improve children's health. Section 1.3 explains our use of average "height-for-age," rather than "stunting," as an

indicator of child health, and considers what figures about stunting reveal and conceal.

1.1 Levels and Trends

Table 1 shows the average height-for-age *z*-scores of Indian children in different years, places, and age groups. It provides separate estimates for children of the 0–59 months and 24–59 months age group because, as we will discuss in greater detail in Section 1.2, although 0–59 months is the age group for which this measure is typically reported, height-for-age from 24–59 months is a more accurate measure of the future health of a population. Table 1 also reports separate estimates in four disadvantaged "focus states"—Uttar Pradesh, Bihar, Madhya Pradesh, and Rajasthan—which together comprise about one-third of the population of India.

The first row of the table shows that the average height-for-age of children under the age of five has increased by about four-tenths of a standard deviation between 2005–06 and 2015–16, from -1.87 in 2005–06 to -1.48 in 2015–16. The next two rows show that although height-for-age has improved slightly more quickly for rural children than urban children, rural children still experience a large height disadvantage relative to urban children.

The numbers in Table 1 imply that the average height-for-age of Indian children under five has improved at a rate of a little less than 0.04 standard deviations per year. How fast is this pace of improvement relative to improvements in height-for-age in other countries? In order to answer this question, we combined data on the height of 5,16,000 children measured in 56 different DHS conducted during 2003–16. These surveys came from different countries other than India (which is excluded from the comparison), but relatively overemphasise sub-Saharan Africa, because more DHS studies tend to be conducted there than in other regions. Averaging over this set of surveys, which measure some countries more than once, the average increase is about 0.03 standard deviations per year, predicting a change of 0.31 over this 10-year period.

So, the linearised pace of increase in India has been slightly faster than the average rate of change found within other countries measured under the DHS Program. But, this fact is not enough to conclude that the NFHS-4 gives Indian children a clean bill of health, because they were very short to begin with.

Table 1: Average Height-for-age *z*-scores of Indian Children

Sample (Places and Ages)	2005–06	2015–16
All India, 0–59 months	-1.87	-1.48
Rural India, 0–59 months	-1.97	-1.59
Urban India, 0–59 months	-1.56	-1.21
All India, 24–59 months	-2.11	-1.69
Rural India, 24–59 months	-2.23	-1.82
Urban India, 24–59 months	-1.76	-1.36
Focus states, 0–59 months	-2.08	-1.74
Rural focus states, 0–59 months	-2.14	-1.80
Urban focus states, 0–59 months	-1.79	-1.47
Focus states, 24–59 months	-2.39	-1.99
Rural focus states, 24–59 months	-2.46	-2.06
Urban focus states, 24–59 months	-2.08	-1.68

Source: NFHS-3 and NFHS-4 (IIPS and Macro International 2007; IIPS and ICF 2017).

Moreover, most of these surveys are conducted in countries that are poorer than India. Section 4 will expand on these observations about the pace of improvement in child height by comparing India's average height-for-age to height in a large number of countries and to the economic status of Indian households.

In addition to comparing children in India to children in other developing countries, it is also useful to consider the comparison of Indian children to the distribution of heights that would be found in a healthy population. Average child height-for-age in India in 2005–06 reflected a distribution of net nutritional outcomes that was extremely poor. One way of understanding this is to note that, in a healthy population, only 3% of children would be as short as or shorter than the average Indian child was in 2005–06. We know this because height-for-age is expressed in normalised scores relative to a healthy population. So, if future cohorts of Indian children continue to become healthier over time, that 3% will become closer to 50%.

Because the average height-for-age of all children in 2005–06 was about the same as the average 24–59-month-olds in the focus states in 2015–16, the same quantitative comparison turns out to still hold true for this group: only 3% of children in a healthy population would be as short as or shorter than the average 24–59-month-olds in the focus states in 2015–16. Expressing the improvement from 2005–06 to 2015–16 in these terms is a way to see that the increase is small relative to the deficit.

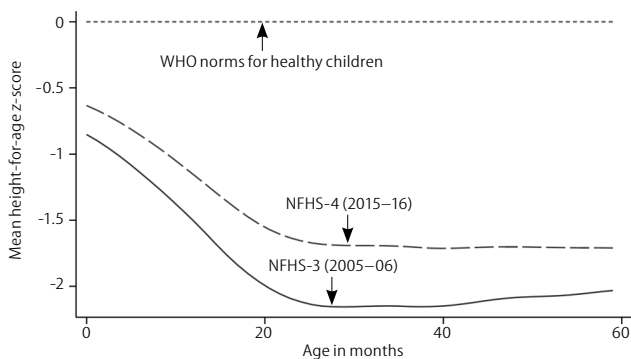
Averaging over all Indian children in the 2015–16 data, the comparable fraction is 7%. In other words, 7% of children in a healthy population would be as short as or shorter than the average Indian child under five in 2015–16. By this metric, India has moved from a score of three to a score of seven, but is still very far from 50. This fact suggests that there is still a long way to go, and that there are still good reasons to invest in improving children's height and health.

1.2 Decline in Average Height-for-age

Figure 1 depicts both change over time and the gap that remains. In Figure 1, the horizontal axis is a child's age in months, and the vertical axis is the mean height-for-age of children at each age. Three lines are plotted: averages from NFHS-3, averages from NFHS-4, and what the average would look like in a healthy population (it would always be at zero by construction). One visible pattern is the large gap between children of all ages and children in a healthy population. At no age are Indian children the same height as children in a healthy population. Another visible pattern is that the gap between Indian children and healthy children is larger for older children than for younger children. The fact that the average height-for-age declines during the first two years of life reflects the accumulating impact of early life health insults on a child's growth. This happens in part because the variance of child height increases in age, given variation in environmental exposure, including in the reference population (Leroy et al 2015). This pattern is well known in the literature and is common in other developing countries as well (Scrimshaw et al 1968).

It is uncommon for children who have experienced the sort of health insults in the first two years that lead to low

Figure 1: Height-for-age of Indian Children by Age, Relative to Healthy Children



Source: NFHS-3 and NFHS-4 (IIPS and Macro International 2007; IIPS and ICF 2017).

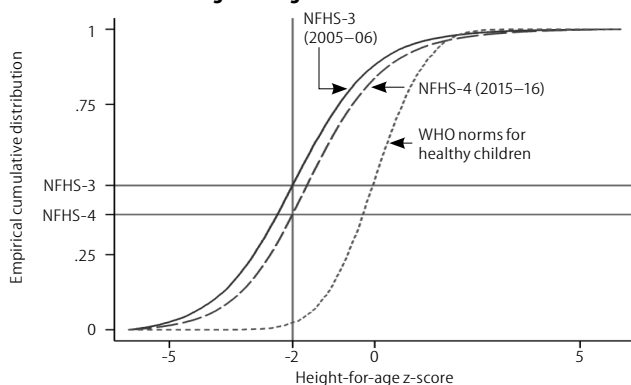
height-for-age at age two to catch up later in childhood (Martorell et al 1994). There is a strong correlation between a person's height at the age of two, and their height as an adult (Bozzoli et al 2009). Therefore, the average height-for-age of children between two and five years is a useful indicator of the health of the next generation of adults. Table 1 showed that in 2015–16, the average height-for-age among children aged 24–59 months was -1.69. Therefore, the height-for-age among children over two is more than half a standard deviation shorter than the average height-for-age among children under the age of two.

1.3 What Dichotomised Stunting Overlooks

Statistics about child height are often reported in popular media as rates of stunting. A “stunted” child is one whose height-for-age z-score is below -2. The “stunting rate,” then, is the fraction of children whose height-for-age is below this cut-off. In 2015–16, 38% of Indian children under five and 41% of rural children under five were stunted, compared to 48% of all children, and 51% of rural children, in 2005–06. Because, as Figure 1 showed, the average height-for-age declines with age, stunting rates are higher among children who are at least two years old than among children under five years old. In 2015–16, 42% of children from 24–59 months and 46% of rural children from 24–59 months were stunted. In a healthy population, only 2.5% of children of any age would have a height short enough to qualify as stunted.

Although stunting rates are commonly reported, they do not offer a particularly informative summary of height among children in a population. This is because child height is not like most standardised entrance exams, where all that matters is “clearing” the exam: healthy population height is not a matter of merely meeting a threshold for minimal qualification. To the contrary, although a population of children with an average height-for-age of -1.95 would have better average health than a population with an average height-for-age of -2.05, having an average height-for-age of -1.5, or -1, or 0 would be better still.

Figure 2 (p 90) offers a visualisation of how much information stunting rates conceal in the case of Indian children. The figure plots the cumulative distribution of child height-for-age among children under five years old in the NFHS-3 and the NFHS-4. A smaller fraction of children in the NFHS-4 have a height-for-age below -2 than in the NFHS-3, so the graph shows that the NFHS-4 stunting rate is lower.

Figure 2: What Dichotomised Stunting Rates Conceal—The Full Distribution of Child Height-for-age

Source: NFHS-3 and NFHS-4 (IIPS and Macro International 2007; IIPS and ICF 2017).

However, compared to the distribution that would be observed among healthy children (which is also plotted in the graph with short dashes), the distribution from the NFHS-3 does not look so dissimilar from the distribution from the NFHS-4. The healthy distribution is far to the right—centred at zero—and rises more steeply, indicating that there is a lower variance of height in a healthy population than in either NFHS survey round. The high variance of height among Indian children points towards the important role for environmental and nutritional insults to health in India, which adds to the variation that would be naturally expected due to genetic variation.

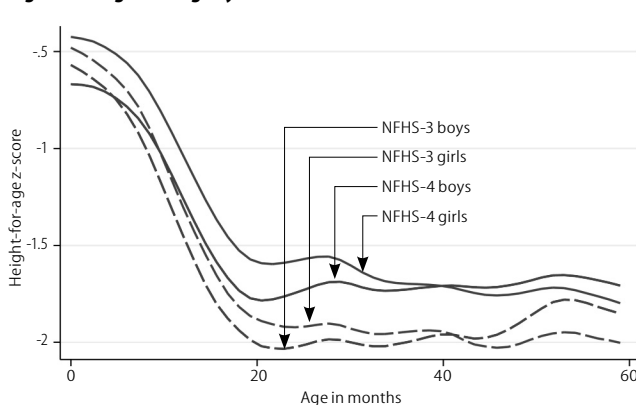
As Figure 2 makes clear, the apparently large decline of 10 percentage points in the stunting rate between 2005–06 and 2015–16 merely reflects the fact that the distribution of child heights in India is steep near -2, not that the distribution has changed substantially over time. Yet, a distribution that is steep near -2 is itself a sign of an unhealthy population: ideally, few children should be in the neighbourhood of such an extreme level of deprivation (even if they turn out to be barely above it). Just as poverty rates are well-understood by economists to be a poor summary of the complexity of the full distribution of economic deprivation (Deaton 2006), rates of dichotomised stunting should similarly be avoided or handled with care.

2 Demographic Heterogeneity within India

Because child height at the population level is an important measure of health and human capital, inequality in child height among population groups is an important measure of inequality in a society. In this section, we investigate what the NFHS-4 tells us about height differences between girls and boys, and among children from different social groups.

2.1 The Heights of Girls and Boys

It is well-documented that women and girls in India suffer severe discrimination in many domains, including education (Drèze and Kingdon 2001), labour force participation (Klasen and Pieters 2015), and food allocation (Palriwala 1993; Coffey et al 2018). Among the more extreme examples of sex discrimination are the sex-selective abortions and neglect of girls² that lead to skewed sex ratios. The NFHS-4 data finds that there were only 916 girls for every 1,000 boys under the age of six

Figure 3: Height-for-age by Child Sex in India

Source: NFHS-3 and NFHS-4 (IIPS and Macro International 2007; IIPS and ICF 2017).

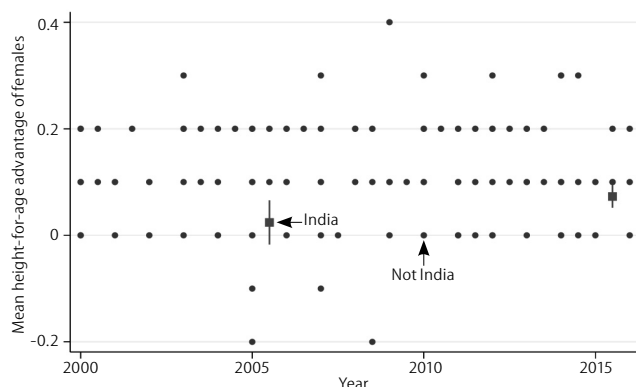
(IIPS and ICF 2017). Most of this difference reflects a skewed sex ratio at birth.

Considering the widespread and severe nature of patriarchy and sex discrimination in India, it is perhaps surprising that prior research has found that, relative to healthy children of their own sex, Indian girls are not shorter than Indian boys. Tarozzi (2012) analyses NFHS-3 data and finds similar height-for-age distributions for girls and boys. Figure 3 extends this finding by plotting a local polynomial regression of average height-for-age at each age among both girls and boys in 2005–06 and in 2015–16. Relative to healthy children of their own sex, Indian girls are slightly taller than boys in early life. By age three, the height-for-age z-scores for girls fall slightly below those for boys. In 2005–06, there was not a statistically significant difference in average height-for-age between girls under five and boys under five; by 2015–16, girls were, on average, slightly taller.

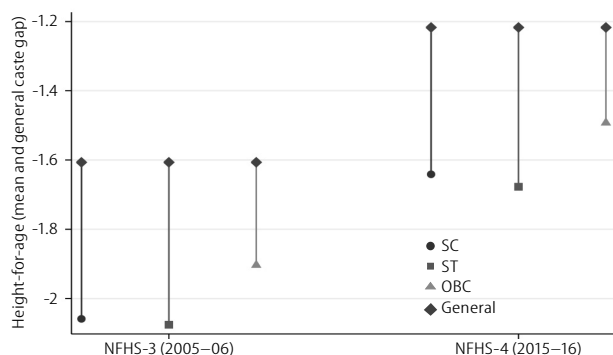
Does the fact that, relative to healthy children of their own sex, girls are as tall, or slightly taller, than boys mean that they do not, in fact, face sex discrimination for the childhood health investments related to height? Are these outcomes evidence that girls receive equal investments in early life health, such as quality breastfeeding, complementary feeding, or care when they are sick?

We suspect not. Although we recognise that this is an area which merits further research, there is reason to think that the similarity in the heights of boys and girls in India indicates discrimination against girls. Prior research finds that female fetuses and children are more robust than male fetuses and children. For example, women who are pregnant with male fetuses are more likely to miscarry than those who are pregnant with female fetuses. Further, in most places and times, boys are more likely than girls to die as children (Drevenstedt et al 2008). If male fragility matters for growth as it does for mortality, then, facing the same early life health insults, boys would grow less than girls in height-for-age terms.

Figure 4 (p 91) tests this idea using the 148 DHS studies conducted in different lower- and middle-income countries in different years between 2000 and 2016 that collected data on child height. It shows that, among children under five, in most surveys, girls have a height-for-age advantage over boys.

Figure 4: The Female Child Height Advantage, in International Comparison

Source: NFHS-3, NFHS-4 (IIPS and Macro International 2007; IIPS and ICF 2017), and measuredhs.com.

Figure 5: Height-for-age by Caste Category, and Gaps Relative to General Caste Children

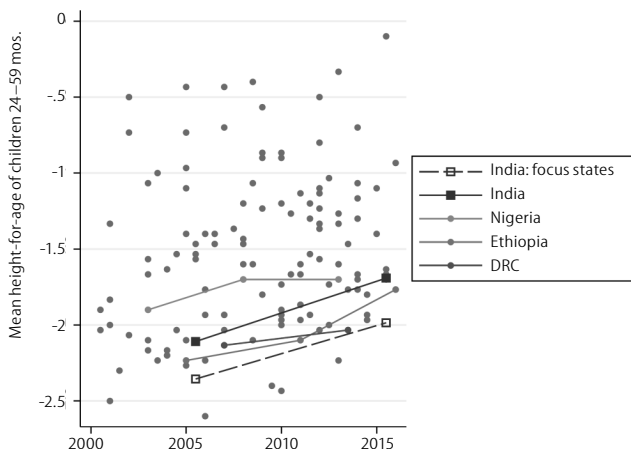
Source: NFHS-3 and NFHS-4 (IIPS and Macro International 2007; IIPS and ICF 2017).

India is among a small group of countries where there is no female height-for-age advantage, or only a very small one. Of the 80 non-India estimates from 2000–09, only four have a negative girl advantage. That is, only four out of 80 countries had a female advantage worse than India's in 2005. Of the 66 DHS that have been collected since 2010, only 16 have a zero or negative advantage, that is, worse than India's in 2015. Although this remains a topic that would benefit from further research, these comparisons strongly suggest that the similar heights of girls and boys in India may actually reflect discrimination against girls.³

2.2 Caste and Tribe

How large are the gaps in height among children from different social groups? Have these gaps narrowed in the last decade? Figure 5 plots average height-for-age among Scheduled Castes (SCs), Scheduled Tribes (STs), and Other Backward Classes (OBCs) in NFHS-3 and NFHS-4. The average for each disadvantaged social group is plotted next to the average height-for-age among general caste children to highlight the size of the gaps.

Figure 5 shows that children in each social group gained about four-tenths of a height-for-age standard deviation, on average, between 2005 and 2015. However, the height gaps between children from disadvantaged castes and general castes remained remarkably similar: in both the survey rounds, SC and ST children

Figure 6: India's Change in Child Height-for-age, in International Comparison

Source: NFHS-3, NFHS-4 (IIPS and Macro International 2007; IIPS and ICF 2017) and measuredhs.com

were about half of a standard deviation shorter than general caste children, and OBC children were about three-tenths of a standard deviations shorter than general caste children. Further, SC and ST children in 2015 were, on average, no taller than general caste children were in 2005.

In light of debates about whether discrimination against Adviasis and members of lower castes has improved in recent years, the fact that height gaps among children from different social groups have not improved in the last decade is sobering. More research into the reasons why there are such unequal child height outcomes among different social groups is needed.⁴

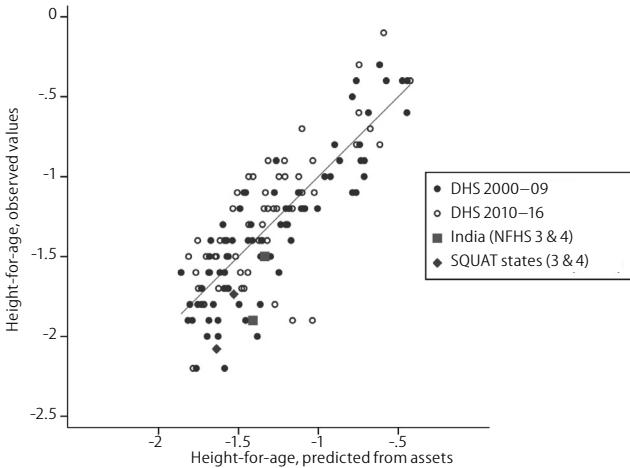
3 Improvement in Child Height Has Been Slow

The decade between the NFHS-3 and NFHS-4 was a decade of many rapid changes in India. For example, according to World Bank estimates, India's real GDP per capita almost doubled.⁵ In the context of such rapid economic change, and of many improvements in health and human development throughout the rest of the developing world (Deaton 2013), we interpret the increase of about four-hundredths of a height-for-age standard deviation per year in India over the current decade to have been slow. To explain how we arrive at this conclusion, we compare improvements in child height in India with the time trend of child height in other countries, and with the time-trend in economic well-being in India.

Figure 6 compares the time trend of average child height-for-age in India with the evolution of child height-for-age in the rest of the developing world studied by the DHS. Each point plots the mean of height-for-age among children aged 24–59 months (after height-for-age faltering has largely occurred), in a DHS conducted between 2000 and 2015. These points reflect 133 such surveys conducted in 70 different countries.

India's NFHS-3 and NFHS-4 are represented by connected solid squares. The hollow squares and dashed line concentrate on the four focus states (Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh). Other DHSs are represented by grey circles.

India was near the bottom of the child height-for-age distribution in 2005–06, and remained near the bottom of the

Figure 7: Child Height-for-age and Asset Wealth, in International Comparison

Source: NFHS-3, NFHS-4 (IIPS and Macro International 2007; IIPS and ICF 2017), and measuredhs.com

distribution in 2015–16. Only a very few countries had average child height as low as the focus states (Uttar Pradesh, Bihar, Madhya Pradesh, and Rajasthan) did in 2005–06. No country measured in recent years has child height-for-age as low as the focus states in 2015–16. Average height-for-age did increase between 2005 and 2015 among children in the focus states, but not by enough to change their position at the bottom of the distribution, or to raise them above poorer large countries such as Ethiopia, Nigeria, and the Democratic Republic of Congo (DRC).

Figure 7 presents a further comparison of India with other developing countries in the DHS. It offers a visualisation of the fact that children in India are short, relative to their economic status. It uses the same set of international DHS rounds as Figure 6. To measure economic status, the DHS asks about a few assets that households tend to own throughout the developing world: electrification, having a *pucca* (not dirt) floor in the house, owning a refrigerator, owning a radio, owning a television, and owning a car.

To construct Figure 7, we used the fraction of households that owned each of these assets in each survey to predict the average child height-for-age. Surveys conducted between 2000 and 2009 are plotted with solid circles; surveys conducted between 2010 and 2016 are plotted with hollow circles. The figure plots the actual average height-for-age observed in a survey (the vertical axis) against the predicted⁶ average height-for-age based on the asset wealth that the households own in a particular country and year (the horizontal axis). By construction, the line slopes up at 45°: on average, children are as tall as they are predicted to be based on their asset wealth. But, some countries are above the line (taller than they are rich) and some countries are below the line (shorter than they are poor).

In both the NFHS-3 and the NFHS-4, India is below the line: child height-for-age in India is shorter, on average, than international trends would predict for a country where people are as economically well-off as they are in India. Children in India got taller, on average, between the two surveys, but not by enough to leave the bottom of the distribution, or to catch up to the height-for-age that would be predicted by India's asset wealth.

In Figure 7, the focus states are plotted as though they were a separate country: the diamonds at the bottom left. The dots from other countries that are near the focus states are generally solid dots, rather than hollow dots. This means that they are from surveys conducted in the past decade, rather than the current one. In other words, child height-for-age in the focus states is not only below what would be predicted based on household asset wealth, it furthermore resembles the very poorest countries when they were measured a decade ago.

4 Why Have Improvements Been So Slow?

In order to understand the slow improvement in average height-for-age in India between 2005 and 2015, we next examine trends in some of the most important determinants of height-for-age in the Indian context. Although the NFHS data does not permit us to determine exactly how much improvement each factor is responsible for, we note that the modest improvements in height are consistent with modest improvements in many of the determinants of height.

4.1 Maternal Nutrition

A mother's health during pregnancy has lifelong effects on the health of her child (Almond and Currie 2011). Undernourished mothers give birth to smaller babies, on average, than mothers who have better nutrition (Hyttén and Leitch 1971). Also, on average, babies who weigh less at birth grow up to be shorter than babies who weigh more (Adair 2007; Black et al 2007). Poor maternal nutrition is one important reason why people in India are shorter than people in other countries (Coffey 2015a, 2015b).

In order to find out whether improvements in maternal nutrition are responsible for some of the improvements in child height that occurred between 2005 and 2015, we would need to know both the size of the effect of maternal nutrition on child height, and the size of the improvement in maternal nutrition between 2005 and 2015. It is difficult to estimate the effect of maternal nutrition on child height because there are no data from India that record both the maternal nutrition a child was exposed to while in the womb, and the child's subsequent height. Although it would be useful to collect such a data set, it would require following women and their children for a period of several years, from before they became pregnant until their children were at least two years old.

The NFHS-4 data do, however, permit estimates of improvements in indicators of average maternal nutrition. Using the NFHS-3 data, Coffey (2015b) estimated pre-pregnancy body mass and weight gain during pregnancy using decomposition and regression methods applied to cross-sectional data. It was found that in 2005–06, 42% of women were underweight before they became pregnant and, on average, women gained only about seven kilograms (kg) during pregnancy. These results, combined with the fact that 59% of pregnant women were anaemic, imply that there were very high rates of maternal undernutrition in 2005.

Applying the same statistical techniques to NFHS-4 data, Coffey (2018) finds that the prevalence of pre-pregnancy underweight improved somewhat between 2005 and 2015. In

2015, 29% of pre-pregnant women were underweight. This figure, although an improvement over the 2005 level of 42%, nevertheless implies that about three in 10 pregnant women started pregnancy underweight. Rates of anaemia during pregnancy improved as well, but not by as much: 50% of pregnant women were anaemic in 2015–16, compared to 59% in 2005–06. Initial estimates suggest that weight gain during pregnancy did not improve. The fact that maternal nutrition is still extremely poor is useful in understanding why improvements in child height have been slow.

4.2 Sanitation

Open defecation is another important predictor of child height in India (Coffey and Spears 2017). Open defecation releases faecal germs into the environment where they can contaminate children's water and food, reach their hands and feet, and be spread by flies. The resulting diseases include worm infections, chronic enteric inflammation, and diarrhoea. Such diseases lead children to grow less tall than they could in a healthier environment—especially in India, where population density is high, so germs can be spread readily.

How much increase in child height-for-age we would expect to result from a decrease in open defecation depends on two factors: (1) how large the effect is of exposure to open defecation on height, and (2) how much average exposure to open defecation changed. Estimating factor (1) would depend on information that is not available in the NFHS-4. But evidence from the existing literature suggests that the size of the effect of local area open defecation on child height is large. A randomised study by Gertler et al (2015) found that moving from everybody in an area defecating in the open, to nobody in the area defecating in the open would cause a linearised increase of 0.47 height-for-age standard deviations. This is quantitatively similar to the estimate of 0.46 considered by Spears (2018).

Factor (2)—the extent of open defecation—can be estimated using data from the NFHS-4. Coffey and Spears (2018) find that between the NFHS-3 and the NFHS-4, open defecation in India went down by 16.4 percentage points, from 55.3% to 38.9%. Combined with the Gertler et al (2015) effect estimate, this change in average exposure to open defecation would predict an increase in average height-for-age of 0.077 of a height-for-age standard deviation, due to improved sanitation, which would be about one-fifth of the overall increase in child height between 2005–06 and 2015–16.

4.3 Other Determinants of Height: Child Feeding

In addition to maternal undernutrition and open defecation, there are several other factors, including the quality and quantity of food that children receive, which also impact height. The WHO and the Indian government recommend that mothers exclusively breastfeed their infants for the first six months of life, because breastfeeding provides appropriate nutrition and protects infants from disease (WHO 2010). The NFHS-4 documents an improvement in exclusive breastfeeding: in 2005, 46% of mothers of children under six months said that they were exclusively breastfeeding, whereas in 2015, 55% of mothers

said that they were exclusively breastfeeding (IIPS and ICF 2017).⁷ This approximately one-percentage-point-per-year improvement in the fraction of infants under six months old who were exclusively breastfed may have contributed to improvements in child height-for-age.

After the age of six months, breastfeeding should be supplemented with age-appropriate foods to promote child growth (Menon et al 2015). The WHO publishes recommendations for dietary diversity and meal frequency for children between the ages of six and 23 months. Perhaps surprisingly, the NFHS-4 finds that a smaller fraction of children between the ages of six and 23 months meet the minimum recommendations than was the case in the NFHS-3. According to published statistics, in 2015, 22% of children in this age range had minimum dietary diversity, compared with 35% in 2005. Further, 36% of children were fed at least the minimum number of times in 2015, compared to 42% of children in 2005 (IIPS and ICF 2017; IIPS and Macro International 2007).

Although it is possible that infant and young child-feeding practices have worsened over the past decade, we find it unlikely, considering the large increase in GDP per capita described above and the large increases in consumption measured in other surveys (Desai et al 2011). Indeed, if anything, a large increase in consumption should be, in part, reflected in the quantity and quality of food fed to young children.

We hypothesise that measurement error could explain these results. It is difficult and time-consuming to measure a person's diet. The sample size of the NFHS-4 is substantially larger than that of the NFHS-3, so it may have been more difficult for survey managers to monitor the quality of each interview in the NFHS-4.⁸ Because infant and child feeding is so important to growth, further research into these trends seems warranted.

A final important factor influencing child height-for-age that may have improved in the last 10 years is respiratory infections. The Million Deaths Study Collaborators (2017) found that among 1–59-month-old children, mortality rates from pneumonia, a severe respiratory infection, fell from 8.3 per 1,000 to 4.2 per 1,000 per year between 2005 and 2015. Because respiratory infections such as pneumonia impact a child's growth as well as the child's survival chances, improvements in respiratory infections are likely also improving child growth.

Further evidence that respiratory infections are likely to be improving is that the use of clean cooking fuel, which is associated with better respiratory health, increased from about 29% of households in India in 2005 to about 45% of households in 2015 (IIPS and ICF 2017; IIPS and Macro International 2007). Most of this improvement was in urban areas, where children already had a height advantage over rural children. The use of solid fuels is still prevalent among rural households: 75% of rural households cook with solid fuels.

5 Conclusions

The release of the NFHS-4 in January 2018 was rightly a cause for celebration among researchers and policymakers concerned with the health and well-being of India's children. After

all, there had been no high-quality, national, individual-level data about child height released in a decade. Unfortunately, though, what the NFHS-4 tells us about child height tempers the reason to celebrate. Children grew taller, on average, by about four-tenths of a height-for-age standard deviation. But change was slow, relative to the magnitude of the challenge, and familiar patterns of disadvantage, discrimination, and

disease are still present. The hundreds of millions of children living in the focus states of Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan are particularly disadvantaged; they are at the bottom of the worldwide distribution of child height-for-age. Because one in five births worldwide now occurs in India, these facts about child height in the NFHS-4 are sobering news for anyone concerned about human well-being.

NOTES

- 1 Volume 48, No 34 of *Economic & Political Weekly* included six discussion pieces written by authors from various disciplines which endorsed the WHO's height-for-age growth reference charts for assessing child height and health in India.
- 2 Historically, girls have had higher mortality rates than boys in India (Das Gupta 1987; Arnold et al 1998). The NFHS-3 found that under-five mortality among girls was 79 per 1,000, compared to 70 per 1,000 among boys (IIPS and Macro International 2007). Thankfully, the NFHS-4 found that girls and boys now face similar under five mortality rates of about 50 per 1,000 (IIPS and ICF 2017).
- 3 These findings echo prior research on female disadvantage in nutrition in India. Marcoux (2002) finds that in the 1990s, India was one of only a small number of countries in which girls were more likely to be wasted (low weight-for-height) than boys. Barcellos et al (2014) analyse height-for-age and weight-for-age in the NFHS-1 (1992–93) data and find that although these nutrition indicators are similar for girls and boys in India, girls do better than boys, on average, in surveys collected in other countries between 1986 and 2009.
- 4 Coffey et al (2018) use NFHS-3 data to decompose differences in height among children from different caste backgrounds. We find that although differences in mother's education and household assets can explain height differences between ST and general caste children, SC children are shorter than general caste children who have the same maternal education and assets.
- 5 The World Bank's constant 2011 PPP series for India increases from a little over \$3,000 in 2005–06 to around \$6,000 in 2015–16.
- 6 We use a linear regression model, with country-level averages of household electrification and household ownership of an improved floor, a radio, a television, a refrigerator, and a car as the predictors.
- 7 We note that, unlike a child's height, whether or not a child is exclusively breastfed is not something the NFHS interviewer can observe; it must be reported by the mother. It is plausible that there would be social desirability bias in mothers' self-reports, as messages promoting breastfeeding until six months are common in both rural and urban India.
- 8 Another aspect of the data that points to the idea that measurement error may be a bigger problem for NFHS-4 than it was for NFHS-3 is that age heaping appears to be more common in NFHS-4. Age heaping is when a person's age is more likely to be reported as a round number (20, 25, 30) than other numbers. The extent of age heaping in a data set is in part a function of how much effort surveyors put into determining a person's exact age.

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