Agriculture and Rural Development in a Globalizing World
Challenges and Opportunities

Edited by
Prabhu Pingali and Gershon Feder

Routledge
Taylor & Francis Group
LONDON AND NEW YORK
earthscan
from Routledge
15 Understanding the multidimensional nature of the malnutrition problem in India

Prabhu Pingali and Tanvi Rao

Introduction
India's high rates of malnutrition have been an object of enigma in academic and policy circles for over two decades now. India's slow progress in combating its malnutrition problem was highlighted most starkly when a comparison between its rates of poverty and malnutrition decline between the mid-1990s and mid-2000s was brought to the fore, with the release of the National Family Health Survey (NFHS-3) in 2005. Despite a robust decline in overall poverty during the period, by approximately 7.8 percentage points (Smith 2015), the proportion of underweight children showed a dismal decline of less than 1 percentage point between the two NFHS surveys spanning the period (Deaton and Drèze 2009; Pathak and Singh 2011). The prevalence of overweight and obesity had increased slightly over the last two NFHS rounds, but the rising trends are more pronounced in urban and high-income populations (Wang et al. 2009).

That complex interactions among various factors are at play in determining nutritional outcomes is amply evident when the Indian experience is viewed both internationally and intranationally. The Indian case has often been compared to sub-Saharan Africa, which has had lower malnutrition levels than India, despite greater poverty and civil unrest. More recently, countries in India's own neighborhood have been shown to outperform it, despite having much lower levels of per capita income. For instance, Bangladesh's successes in scaling up health-related efforts, like gains in immunization coverage or vitamin A supplementation, have been attributed to women-centered and highly focused health programs and a wide network of community health workers (Chowdhury et al. 2013). Holding wealth constant, it has also been documented that children in West Bengal are one-tenth of a height-for-age z-score (HAZ) standard deviation (sd) shorter than children in Bangladesh, and these findings have been correlated with differences in open defecation between the two genetically similar populations (Ghosh, Gupta, and Spears 2014). Between 1990 and 2009, India's rank, in comparison to its five South Asian neighbors – Sri Lanka, Bangladesh, Bhutan, Nepal, and Pakistan – improved in terms of GNI per capita, while its rank in the proportion of underweight children slipped to the last spot (Drèze and Sen 2011).
State-level malnutrition in the country also offers a diverse picture. In 2005, across 15 major Indian states, stunting prevalence among children under five ranged from 25 percent in Kerala to 57 percent in Uttar Pradesh, and the prevalence of underweight from 23 percent (Kerala) to 60 percent (Madhya Pradesh) (Kanjilal et al. 2010). While, on average, State Net Domestic Product (SNDP) is positively associated with HAZ, Indian states that have experienced more economic growth saw less of an increase in HAZ between 1998–99 and 2005–06. Moreover, the cross-sectional relationship between SNDP and HAZ was stronger in 1998–99 than in 2005–06 (Coffey, Chattopadhyay, and Gupt 2014). How then can India make progress in tackling its persistently high levels of malnutrition? Much of the academic discourse around Indian malnutrition today relies on NFHS-3 data that are over a decade old. Undoubtedly, crucial pieces in the Indian puzzle will remain out of place, until more up-to-date and nationally representative anthropometric data are disseminated and used. Recent health and nutrition data releases by the Indian government will undoubtedly spur research to help foster a deeper understanding of what has or has not worked in the past decade to combat malnutrition in the Indian context. Already, numbers emerging from UNICEF's Rapid Survey of Children (RSOC), in July 2015, indicate unprecedented changes in India's nutrition profile. Reported figures show substantive overall drops, in comparison to the 2005 data, in all three child undernutrition measures, although state-level figures remain varied. While progress is seen in both economically prosperous states, such as Maharashtra (decline in underweight prevalence of 12 percentage points), and laggard states, such as Madhya Pradesh and Bihar (drops in underweight prevalence of 24 and 19 percentage points, respectively), states such as Uttar Pradesh and Gujarat seem to provide a less favorable contrast. Moreover, reports based on the RSOC reveal much less progress in reducing the proportion of underweight adolescent girls, with only four Indian states succeeding in doing so in the past decade.

In this chapter, we bring together several strands of research on malnutrition in India in a comprehensive narrative synthesis of the existing literature. By focusing exclusively on comparable anthropometric outcomes, we throw light on the relative strength of different nutrition determinants and interventions. We also differentiate rigorous studies from ones with poor internal validity, to highlight gaps in the literature. With this, we hope to set the stage for further research with up-to-date anthropometrics, relevant to the new and changed environment around nutrition in India. We do not restrict our review to a particular type of nutrition intervention, but instead cover a breadth of nutritional determinants and interventions to populate evidence along each of the four interlocking pathways shown in Figure 15.1, which are generally thought to improve child and adult nutrition. A detailed description of Figure 15.1 can be found in Pingali, Ricketts, and Sahn (2015).

Readers may also want to draw parallels between the framework presented here and UNICEF's (1990) framework, which has commonly been the de facto choice for conceptualizing the multiple drivers of undernutrition. Our framework explicitly accounts for household-level and intrahousehold determinants
of individual nutrition outcomes. It provides a clearer representation of the drivers of household access to food (in terms of quantity, quality, and diversity), as well as the factors that determine individual intake and absorption of nutrients.

In general, macroeconomic growth, accompanied by an augmentation of household incomes (Quadrant 1), is necessary for a household to be able to afford a sufficient diet in terms of both quantity and quality of food. In India, where a predominant fraction of the malnourished is rural and belongs to agricultural households, income is determined in significant part by agricultural output and is subject to seasonality. Moreover, households are often unable to smooth consumption, facing high transaction costs and missing markets for nutritious foods, and also suffer from substantial information and knowledge gaps that may hinder the consumption of a diverse and micronutrient-rich diet and the practice of proper child-feeding practices. Therefore, to address adverse anthropometric outcomes, especially among young children, it is necessary to ensure access to a micronutrient-rich diet (Quadrant 2). Potentially delivered via supplementary feeding, food fortification, or crop diversity, such diets need
to be actively promoted. Government interventions and food-based safety nets to address malnutrition are relevant here.

The intrahousehold allocation of resources (Quadrant 3) is a crucial determinant of how household-level food access translates into individual-level nutrition outcomes. When household incomes/resources are not pooled, the identity of the individual with access to resources (e.g., fathers versus mothers) can have a considerable effect on outcomes of vulnerable groups, like children and women. Joint familial relations and a pronounced preference for sons heighten the role of such factors in the Indian context. Finally, it is crucial that nutrient intake translates into nutrient absorption, which can be greatly inhibited by gastric and parasitic infections and diarrheal disease. Access to proper sanitation and adequate hygiene (Quadrant 4) are essential to ensure nutritional improvements via this pathway.

**Methodology**

As discussed in the previous section, this review cuts across different types of nutrition determinants and interventions, but focuses solely on either studies that explain child stunting, underweight, or wasting in terms of prevalence or z-scores, or studies that explain analogous adult underweight (low body mass index [BMI]) outcomes. Primarily, our focus is on young children because stunting/underweight/wasting classifications follow international reference standards that are applicable, at a country-level, only for young children, typically under five years of age (de Onis and WHO Multicentre Growth Reference Study Group 2006). Studies for the review were screened using a combination of methods. First, we started with a list of widely cited studies relevant to each quadrant, which met our inclusion criteria, and then searched for other relevant and related studies by a method of “forward” and “backward” snowballing of reference searches (Hagen-Zanker and Mallet 2013). Then we searched three economics databases – RePec, AgEcon Search, and Econlit – and one biomedical database – MEDLINE – with a keyword search using a combination of keywords related to “India” and “malnutrition.” Any study not previously found during snowballing was screened for inclusion, and then either retained or discarded. While we concentrate this review primarily around articles published in academic, peer-reviewed journals, some well-cited working papers from the last five years have also been included in the review, for completeness.

The main inclusion criteria during screening for studies retrieved via the aforementioned search methods were that the studies should (1) have a population focus on young children and adults in India; and (2) conduct econometric/statistical analysis with anthropometric measures as the outcome of interest. In addition, we include only studies published between 1990 and 2015, as this is the period wherein national tracking of anthropometrics in India was commenced and during which time an explicit recognition of India’s lack of progress in tackling malnutrition was made. Finally, only articles published in English language journals and those that could be digitally retrieved were included.
More than half of the studies that we review are based on one of three rounds (1992-93, 1998-99, and 2005-06) of the NFHS data. This is not surprising, given that NFHS is the only nationally representative anthropometric data, comparable across years, that are available for India. Another survey used, which is also nationally representative and collects a different set of complementary data along with anthropometrics, is the Indian Human Development Survey (IHDS), released in 2005. Although IHDS data used by nutrition researchers, to date, have been cross-sectional, a subsequent round of the data set, pertaining to the years 2011-12, was released in August 2015 and makes available the opportunity for panel data analysis in the future. Regionally focused and smaller-scale surveys, like the Young Lives Survey and the HUNGAMA7 data set, have also been used by researchers to draw specific insights on the nature and causes of malnutrition. A substantial and informative body of evidence is also available on the determinants of nutrition outcomes, based on randomized evaluations and case-control studies.

A subset of papers included in our narrative synthesis is organized by quadrant, effect size, and extent of control of confounding effects, in Table A.15.1a (children) and Table A.15.2a (adults). Both tables are accompanied by additional details regarding the included predictor variables – that is, the precise variable definition and unit of measurement of the variable, which are presented in Tables A.15.1b and A.15.2b. Papers discussed in the narrative synthesis but not included in Tables A.15.1a and A.15.2a were excluded for the sake of comparability. The main reason for exclusion was nonstandard measurement of malnutrition. Some medically focused studies and some non-rigorous studies with extremely large effect sizes were also excluded. We also distinguish between statistical significance and effect size in the two tables – all studies, irrespective of effect size, are placed in column 1 of Tables A.15.1a and A.15.2a if the effects found are not statistically significant.

Since we do not restrict our analysis to studies that employ a particular type of analytical method (e.g., randomized controlled trials, or RCTs), the reviewed studies vary greatly in terms of the analytical models they employ and the extent to which they account for confounders in establishing cause and effect. To help readers discern between the quality of included studies, purely on account of established causality and internal validity of the study, the studies were classified into three groups – low (L), medium (M), and high (H) – to signify the extent to which they control for confounding effects.

Studies classified as being low control (L) use cross-sectional data, include few controls, or omit important controls while estimating the relationship of interest. Findings of these studies are not to be interpreted as causal. Studies with medium control (M) also mainly use cross-sectional data, but include a comprehensive set of relevant control variables, or use other causal techniques, such as instrumental variables or matching methods. High control (H) studies include randomized control trials (RCTs), panel data with appropriate fixed effects, or multiple methods that yield consistent results.
Crosscutting findings

Looking across Tables A.15.1a and A.15.2a, it is at first obvious that a lot more research informs pathways for addressing child malnutrition in India (31 distinct studies) as compared to adult malnutrition (6 distinct studies). Moreover, around half of the studies focused on adult outcomes are of low quality, compared to a quarter of such studies that look at child malnutrition. Given that better maternal nutrition has important contemporaneous and intergenerational implications for health and productivity, thinness among adults, especially women, is an important avenue for future research.

Out of the 31 distinct studies included in Table A.15.1a, 8 are low-quality, 15 are medium-quality, and 8 are high-quality. Out of the six distinct studies in Table A.15.2a, three are low-quality, two are medium-quality, and only one is high-quality. In Table A.15.1a, Quadrants 2 and 3, which deal with access to a good-quality diet and the intrahousehold allocation of resources, respectively, have the highest concentration of research. While all four quadrants in Table A.15.2a are sparse, the foci of Quadrant 2 (d subs) and Quadrant 4 (sanitation, water, and hygiene) are particularly understudied.

Focusing exclusively on high-quality studies, what does the current literature tell us? First, daily supplementation under India’s Integrated Child Development System (ICDS) has more recently proven to be an effective strategy for producing appreciable effects in reducing child malnutrition for young children under two (Jain 2015). If we are particularly interested in child nutrition as an outcome, then the government’s ICDS program has a better track record than its Public Distribution System (PDS) (Tarozzi 2005). Secondly, two features of Indian families have demonstrably serious implications for children’s and women’s health – the birth order of the child (Jayachandran and Pande 2013) and the rank of the daughter-in-law in joint families (Coffey, Spears, and Khera 2013). Both these features are tied to elder son preference in India, with children born later having worse nutrition outcomes if the firstborn is a son, and with wives of the eldest sons enjoying greater decision-making autonomy in a household, as compared to wives of younger sons. Thirdly, although the association between open defecation and child anthropometrics (specifically stunting) is strong, randomized evaluations of toilet construction programs in India (Clasen et al. 2014; Patil et al. 2014) have failed to show statistically significant effects on malnutrition. This is likely due to poor usage of the current pit latrine toilets being promoted in rural areas, lack of awareness around toilet usage, and norms among Hindus regarding defecating at home and handling fecal matter (Coffey et al. 2014).

The rest of the chapter follows with a narrative synthesis pertaining to each quadrant in the next four sections. Each section summarizes quadrant-specific findings in its last paragraph. We conclude in the final section by highlighting avenues for future nutrition research. The tables are in the appendix.
Detailed synthesis by quadrant

Economic growth and household incomes

At the country level, it is clear that at least until 2005, India’s progress in tackling malnutrition has been discordant with its pace of economic growth and poverty decline. As can be seen in Quadrant 1 of Table A.15.1a, there is some evidence to suggest that macro-level changes in economic performance at the state level might also bear little association with improvements in metrics of child malnutrition (Subramanyam et al. 2011). On the other hand, although increases in income at the household level seem to have an appreciable effect in reducing child malnutrition (Kanjilal et al. 2010; Pathak and Singh 2011, Bhagowalia, Headey, and Kadiyala 2012), it is important to note that large increases in household income are required to achieve this end. Nevertheless, studies that examined the nutrition consequences of wealth inequality in India (Joe, Mishra, and Navaneetham 2009; Kanjilal et al. 2010; Pathak and Singh 2011; Chalasani 2012) repeatedly have found poor nutritional outcomes to be disproportionately concentrated among the poor, suggesting that household income and factors influencing access to good health are indeed intimately tied. Additionally, Quadrant 1 of Table A.15.2a discusses the effect of the nature of work on nutrition outcomes for adults. While the BMI penalty of manual labor work for adults is evident, the precise size of the effect is not robust, due to the low level of confounder control employed by the studies that have examined this relationship (Subramanian and Smith 2006; Headey, Chiu, and Kadiyala 2012).

What do empirical investigations of economic growth at the state level find? Is the existing analysis of the link between state-level economic growth and malnutrition persuasive? In general, the findings have been mixed, and have been found to depend on the level at which the relationship is modeled, as well as on the selection of control variables. Moreover, limited variation in economic growth across states, because of a small number of states and few time periods of data, is undoubtedly a major limitation to current research. Using three rounds of NFHS data and modeling individual-level child stunting, underweight, and wasting as functions of SNDP per capita growth, with child- and mother-level controls, Subramanyam et al. (2011) found no statistically significant associations of SNDP per capita growth for either outcome, in their preferred specifications. The authors found a unit increase in SNDP per capita (in 5,000 rupee terms) to be associated with a 0–3 percentage point reduction in the likelihood of the individual being undernourished. A 5,000 rupee increase in per capita SNDP growth is roughly one-third of the mean per capita SNDP increase that has taken place in the country between 1993 and 2005. Their estimates suggest that if Bihar grew exactly the way it did between 1993 and 2005, undernutrition in the state would fall by less than 0–5 percentage points.

Findings of two other papers (Radhakrishna and Ravi 2004; Coffey, Chattopadhyay, and Gupt 2014), which used similar data but modeled both economic progress and the prevalence of undernutrition at the state level, found an inverse
and statistically significant relationship between the two, albeit one that has weakened over time. It is striking that in 1998, a difference of 5,000 rupees in SNDP per capita was associated with a 7 percentage point difference in stunting prevalence and more than a quarter of a standard deviation difference in average HAZ scores. However, in 2005, a 5,000-rupee difference in SNDP per capita was found to be associated with a 3 percentage point difference in stunting prevalence and a smaller difference in average HAZ scores to the magnitude of 0.13 sd (Coffey, Chattopadhyay, and Gupt 2014). As a caveat, it is important to keep in mind that both Radhakrishna and Ravi (2004) and Coffey, Chattopadhyay, and Gupt (2014) modeled state-level variables cross-sectionally and presented bivariate associations with the intention of drawing attention to trends.

Another pathway through which macroeconomic conditions can influence nutrition outcomes is through food prices. Children’s consumption of different food groups in India dropped considerably, as food prices spiked during the global food crisis of 2007-08. Vellakkal et al. (2015) documented that the change in average daily rice intake of children between 2006 and 2009 was around 33 grams/day, which was associated with a 0.165 sd decline in child weight-for-height z-scores (WHZ).

Trends in economic inequalities with regards to malnutrition, which refers to the degree to which malnutrition rates differ between the poor and the rich, support the notion that overall improvements in state-level malnutrition might mask the slow progress/stagnation of the economically disadvantaged on this front (Joe, Mishra, and Navaneetham 2009; Kanjilal et al. 2010). States like Punjab and Tamil Nadu that achieved higher declines in child underweight during 1992-2006 (with relative change in prevalence being more than 20 percent) also registered higher increases in economic-based malnutrition inequalities, implying a larger concentration of the poor in the malnourished category (Pathak and Singh 2011). Similarly, a regression-based inequality decomposition by Chalasani (2012) found that the largest contributions to wealth-based malnutrition inequality come from inequalities in maternal education, followed by birth order.

Insights from two separate nationally representative data sets reveal that only large income increases make a difference (Kanjilal et al. 2010; Pathak and Singh 2011; Bhagowalia, Headey, and Kadiyala 2012). For instance, Bhagowalia, Headey, and Kadiyala (2012) used IHDS-2005 data and found the effects of increases in household income to be very modest. They found no statistically significant differences in HAZ scores of children between the 1st and 4th income quintiles; however, compared to children in the 1st quintile, those in the 5th quintile had 0.43 sd higher HAZ scores. Similarly, they found no statistically significant differences in the WHZ scores of children in the 1st-3rd quintiles, but compared to children in the 1st quintile, children in the 4th and 5th quintiles had WHZ scores that were statistically significantly higher.

Is malnutrition more responsive to income in nonagricultural or agricultural households? Several studies, including Babu, Thirumaran, and Mohanam (1993) and Bhagowalia, Headey, and Kadiyala (2012), suggested that malnutrition in
nonagricultural households and urban areas is more responsive to income.

Although specific features of the agricultural system have great potential for improving malnutrition (see Pingali, Ricketts, and Sahn [2015] for a detailed review), overall differences in agricultural productivity at the state level have not been shown to be associated with large differences in malnutrition outcomes in India. For instance, a 1,000-rupee increase in the gross value of output from agriculture and livestock per hectare of gross cropped area (GVOAL/Ha), an increase amounting to 3.33 percent of the mean GVOAL/Ha, was found to be associated with a 0.007-point reduction in an author-constructed Normalized Adult Malnutrition Index (which varies between 0 and 1); and a 1,000-rupee increase in per capita gross state domestic product from agriculture and allied activities (PCGSDPAA), an increase amounting to 12.5 percent of the mean PCGSDPAA, was found to be associated with a 0.032-point reduction in an author-constructed Normalized Child Malnutrition Index (NCMI) (Gulati et al. 2012).

Effects of seasonality in agriculture are also stark. A study collecting data from villages near Pune City in Maharashtra found that, after controlling for the sex of the child, parity of the mother, gestation, prepregnancy weight, maternal caloric intake at eighteenth week, and maternal activity at the twenty-eighth week, one week of in utero exposure to the winter season (harvest season) was associated with an increase of 5.6 grams in birthweight. Thus, babies born to women who are exposed while pregnant to the entire harvest season of 16 weeks are likely to have birthweights higher by 90 grams (Rao et al. 2009). The nature of work, in particular calorie expenditure based on physical labor, is also purported to affect adult BMI. While controlling for wealth, health, education, and location, in comparing the BMI of adults in different occupational groups, agricultural workers were found to have the lowest average BMI among both women and men (Headey, Chiu, and Kadiyala 2012). More generally, there exists a BMI penalty for manual work occupations. With the same set of controls, Headey, Chiu, and Kadiyala (2012) also established that, compared to the reference category of those who do not work, those in manual work have lower average BMI by 0.46 points. Subramanian and Smith (2006) found a lower likelihood of 6 percentage points for having low BMI if an adult is engaged in manual work, with the same reference category as earlier, but they could not establish this effect as statistically significant.

In summary and with reference to Table A.15.1a, the effects of macro-growth on child malnutrition outcomes are small (Subramanyam et al. 2011; Coffey, Chattopadhyay, and Gupt 2014). On the whole, this debate is currently taking place in a data vacuum in the Indian context. Moreover, malnutrition inequalities on account of economic inequalities are pronounced, and only very large increases in household incomes seem to produce appreciable results (Kanjilal et al. 2010; Pathak and Singh 2011; Bhagowalia, Headey, and Kadiyala 2012). Additionally, in Table A.15.2a, the effects of adult employment on adult nutrition are inconclusive and are to be treated with caution, owing to the low level of confounder control (Subramanian and Smith 2006; Headey, Chiu, and
Kadiyala 2012). The limited impact of economic growth on nutrition in India can be attributed to the multidimensional nature of the problem. Unlike in other countries, income growth has not translated into women's empowerment and the consequent improvement in intrahousehold equity with respect to access to micronutrient-rich food. Also, India has lagged far behind countries of similar economic status in terms of investments in clean drinking water and access to toilets. The adverse consequences of poor sanitary conditions for nutrition are discussed in a later section.

Access to micronutrients and diverse diets

High levels of hidden hunger in India are evident, and of grave concern, with markers such as stunting, iron deficiency anemia, and vitamin A deficiency all being concurrent and highly prevalent. Elsewhere in the developing world, as in Latin America, low levels of hidden hunger have been achieved with the simultaneous deployment of micronutrient interventions, nutrition education, and basic health services (von Grebmer et al. 2014). Income growth alone may not be enough to address hidden hunger at the household level because critical nutrition inputs—such as the consumption of a balanced, nutritious diet and proper child-feeding practices—suffer because of information and knowledge gaps (Malhotra 2013).

The Indian government's single largest machinery to combat malnutrition is the Integrated Child Development System (ICDS), which is a village-level institution manned by an “anganwadi worker” responsible for the supplementary feeding of children aged 0–6 years and pregnant and lactating mothers. Earlier evaluations of the ICDS program, based on NFHS 1 and NFHS 2 data, failed to find significant effects of the program (Lokshin et al. 2005). Partly, this could be due to lower coverage of the program at the time, larger inefficiencies in the working of the program early on, and a focus on only the “presence of an ICDS center” as the exposure measure. More recent evaluations of the program and of other specific interventions that aim to increase the efficiency of the program in some way have found appreciable effects on child malnutrition, indicating that the program may have improved in its later years.

One study that uses NFHS-3 data and controls for endogenous program placement by matching individuals on the basis of propensity scores, which are estimated using individual characteristics, village population, and other community-level indicators, found relatively small effects of the presence of an ICDS center in a village, to the magnitude of 0.10 HAZ sd for boys and 0.07 HAZ sd for girls. While the effects are relatively small, they are statistically significant, and the same model yielded no statistically significant effects of the ICDS program when estimated with earlier data (Kandpal 2011). A separate study, also using the most recent NFHS data, compared anthropometric outcomes of children in the 0–2 years age group who received daily supplementation from the ICDS with those of children who did not, matching on the basis of a relatively exhaustive set of controls and state fixed effects, and found daily supplementation to be associated with a 0.4 sd increase in HAZ—a relatively large effect (Jain 2015).
There is also some research that indicates that alterations in the working of the ICDS can yield favorable results, as opposed to the “business-as-usual” working of the program. A controlled experiment in the urban slums of Chandigarh in Punjab revealed that combining a performance-for-pay incentive treatment for *anganwadi* workers who were giving mothers information, in the form of recipe books with nutritious recipes for complementary feeding of young children, can positively affect child underweight status (Singh 2015). The author found that while compared to the control group, individually, each of these treatments did not have an impact, but the combined treatment increased WAZ scores by approximately 0.10 sd and also reduced the prevalence of wasting. The complementarity is suggested to be driven by better mother–worker communication and by mothers feeding more calorific food at home. Programmatic evidence allows us to study the effects of intensifying ICDS outreach by having village volunteers aid an *anganwadi* worker in providing services, in the context of Jharkhand’s *Dular* program (Dubovitz et al. 2007). Comparing underweight outcomes of children in villages with and without the program, and with some controls in place, the authors found that the average WAZ score in the program villages was higher by 1.29 WAZ sd, which is a very large effect, though undoubtedly biased due to nonrandom placement of the program.

Another governmental program which has the potential to appreciably impact the nutritional status of children attending school is the Mid-Day Meal Scheme (MDMS). Using the calendar year of birth as an instrument for MDMS participation, Singh, Park, and Dercon (2012) provided evidence that access to MDMS in school can result in catch-up growth for children adversely affected by drought during the critical ages of growth. They found that children with access to MDMS had higher WAZ (0.62 sd) and HAZ (0.98 sd) than children without access, with both sets of children having been exposed to drought when they were less than two years old.

India’s national vitamin A program is characterized by low coverage with only around 20 percent of Indian children between 1–5 years having received vitamin A supplementation according to NFHS-3 data. With a few child, parent, and household-level controls in place, it is estimated that children receiving vitamin A supplementation had lower malnutrition prevalence, modest in magnitude, with stunting and underweight being approximately 7 percentage points lower and with no effects observed on wasting (Semba et al. 2010). However, as is apparent in Table A.15.1a, more rigorous studies are required to examine the efficacy of vitamin A supplementation in the Indian context. One study, with poor internal validity, examined the effect of iodized salt on child WAZ, finding it to be associated with a 0.08 sd increase in child WAZ (Kumar and Berkman 2015). Even food fortification studies of an experimental nature present mixed findings. While Bhandari et al. (2001) did not find significant effects of fortified milk cereal (along with nutritional counseling) on the proportion of wasted or stunted children, another separate milk fortification RCT found moderately high and statistically significant impacts across all three child undernutrition metrics for children between 1–4 years (Sazawal et al. 2010).
The malnutrition problem in India

Even though dietary diversity and the production of food crops are hypothesized to have favorable effects on nutrition outcomes, in the Indian context with current data sets and methods utilized, the evidence is mixed. Using two measures of dietary diversity—a dietary diversity score (a count of the number of food groups consumed) and the budget share spent on different food groups—Bhagwalia, Headey, and Kadiyala (2012) established that there were favorable income effects on dietary diversity. However, controlling for household income, they did not find that either dietary diversity measure had significantly impacted child stunting or wasting. However, Menon et al. (2015) focused on child-feeding practices of exclusively young children (<24 months) and found that, out of the eight recommended WHO Infant and Young Child-Feeding (IYCF) practices, an indicator of diet diversity (continuous indicator) was most strongly associated with reducing malnutrition. They found a 1 point increase in the dietary diversity score increased HAZ by 0.09 sd, WAZ by 0.06 sd, and WHZ by 0.02 sd. WHO indicators related to appropriate breastfeeding timing and timely introduction of semi-solid food were not found to be statistically associated with increases in HAZ/WAZ/WHZ. Controlling for household income and socioeconomic status, the fraction of food consumed from one’s own farm was not found to statistically impact child stunting, underweight, or wasting, nor stunting and wasting of adolescents and adults (Parasuraman and Rajaretnam 2011).

A set of well-identified and rigorous studies has failed to find that food price subsidies in India and elsewhere improve nutrition outcomes. In a prominent study on the nutrition effects of India’s Public Distribution System (PDS) for food grain, Tarozzi (2005) used the staggered rollout of the NFHS 1 survey, in the state of Andhra Pradesh, which collected data on child weight-for-age between April and July 1992. In January 1992, the price of PDS rice in Andhra Pradesh saw a marked increase. Modeling child weight as a function of child age, the number of months spent by a child in the high price regime, and other controls, the study found statistically insignificant effects of an additional month spent by a child in the high food price regime on his/her WAZ, and the author concluded that the program may not have been acting as an effective food safety net from the outset. Using three rounds of the NSS data between 1993 and 2005 and instrumental variable (IV) methods to model nutritional intake, as a function of the extent of PDS subsidy enjoyed by a household, Kaushal and Muchomba (2015) also failed to find significant effects of the subsidy on nutrient intake and found that the subsidy might have altered the source of nutrient intake from coarser grains to sugar and sugar products. Here, some evidence is also provided to show that the subsidy led to a modest reduction in total food expenditure (which is expected in the case of a food subsidy, if households do not divert expenditure to unsubsidized foods) and a concomitant increase in expenditure on non-food items.

However, it is important to note that both the working of the PDS and the context in which it functions vary greatly from state to state in India. For instance, in Chhattisgarh, where immediately after its formation in 2000, the
government instituted unprecedented reforms in procurement and distribution of PDS rations, Krishnamurthy, Pathania, and Tandon (2014) found favorable impacts of the program on consumption of pulses and animal-based proteins, which can have favorable impacts on anthropometric outcomes, though these outcomes have not be directly measured. Moreover, for subsistence farmers, the PDS could also have beneficial crop diversification effects – an angle that is yet to be explored extensively in the literature.

Table A.15.1a summarizes the relative efficacy of the government’s food and micronutrient interventions, as well as dietary diversity at the household level. As can be seen, a rigorous evaluation of the ICDS program showed large impacts of the program on child anthropometrics (Jain 2015), while a relatively less rigorous exercise showed smaller effects (Kandpal 2011). However, the two studies used different measures of the program. The effect of the PDS on child anthropometrics is insignificant (Tarozzi 2005). Across both tables, the bulk of the studies that looked at food supplementation and dietary diversity found small effects – though a lot can be done to address these channels more rigorously.

**Intrahousehold allocation of resources**

The intrahousehold status of individuals is widely acknowledged as a determinant of individual nutrient and food intake and an important link between household food availability and individual nutritional status. Several indicators of women's status in the literature consistently rank women in the countries of South Asia as lower in comparison to their counterparts in Asia, Africa, Latin America, and the Caribbean (Haddad 1999). Low intrahousehold status has been shown to impact not just a woman's health and nutrition but also that of her child, both in utero and otherwise, because of a woman's compromised capacity to care for her child in the latter case.

Most of the existing literature that explores aspects of intrahousehold distribution in India measures women’s status by levels of education, freedom of mobility, autonomy in decision-making, incidence of domestic violence, or intrahousehold rank. Gender and birth order of children have also been shown to be an important determinant of their nutritional status. Much of the work in this line of research relies on survey data (predominantly, the NFHS data) and survey responses with respect to mobility, autonomy, and violence questions, which are most certainly endogenous to unobserved women’s characteristics. On the other hand, education, employment status, and intrahousehold rank are more objective measures of a woman’s status.

As can be seen in Table A.15.1a, two studies (Bose 2011; Imai et al. 2014), which explored the effects of a woman’s education on her child’s anthropometrics, did not find large effects of the woman’s education. Partly, this can be explained by the fact that the studies were non-experimental and thus unable to capture useful independent variation in women’s education, after controlling for factors like household standard of living. Both studies used NFHS data and estimated cross-sectional OLS models with controls. Imai et al. (2014) used the
The malnutrition problem in India

2005 round of NFHS data to look at the effect of the ratio of maternal education relative to paternal education on child malnutrition, after controlling for the total years of education of the father and the mother. They found relatively small effects to the magnitude of 0.02 and 0.06 HAZ sd for the categories of stunted and severely stunted children, respectively. They found no effects on WAZ or WHZ. Bose (2011) also used the NFHS-3 dataset but operationalized the education variable in the form of a continuous measure of the years of completed schooling and found that an additional year of schooling was associated, on average, with 4 percentage points lower underweight probability for children.

Another study (Subramanian and Smith 2006) compared women's underweight status across different education categories, using NFHS-2 data, and found that compared to women with more than 15 years of education, women with 6–8 years of education have 28 percentage points higher underweight probability. If these results are to be extrapolated to draw inference for the marginal effect of one year of education, the effects are similar to the findings in Bose (2011). However, these estimates are not to be interpreted as causal. Bose (2011) also looked at the impact of maternal employment in a model similar to the one employed for education status to document that the children of working mothers have 15 percentage points higher underweight probability, compared to children of mothers who are not employed. However, again, these effect sizes are only correlations, as the study controls for limited confounders in its analysis.

NFHS surveys measure autonomy as freedom of mobility (answers to questions such as whether the woman needs permission to go to the market) and independence of decision-making (e.g., whether she can set aside money to use as she wills). In NFHS-3 data, Imai et al. (2014) found that freedom of mobility of mothers is associated with an increase of 0.09 HAZ sd of their children. Using NFHS-2 data from Andhra Pradesh, Shroff et al. (2009) estimated cross-sectional logistic regressions to estimate that mothers having financial autonomy and mobility reduce the probability of their children’s stunting by ~27 and ~41 percentage points, respectively. However, even within the same data sets, estimates of the autonomy variables are not robust and are sensitive to employed controls, as is seen not only in the differing estimates of Imai et al. (2014) and Shroff et al. (2009) but also in Bose (2011), who did not find any significant effects of women’s autonomy on child underweight using NFHS-3 data.

Similarly, evidence on the effects of domestic violence on child and adult malnutrition is mixed, and also sensitive to the measure of violence used. A dummy variable for “whether or not a wife thinks that a husband is justified in beating his wife when she is unfaithful to him,” as a measure of domestic violence, was not found to be statistically significantly associated with child anthropometrics (Imai et al. 2014). On the other hand, using a categorical measure of self-reported (by women) domestic violence in NFHS-2 data, authors estimated a multinomial, logistic framework, and reported that, compared to the reference category of “never been abused,” women who faced abuse by a family member more than once in the last 12 months had children who were more likely to be stunted and wasted by 14 and 18 percentage points, respectively, and the women
themselves more likely to be underweight by 21 percentage points. (Ackerson and Subramanian 2008).

Robust effects of family composition on the intrahousehold allocation of resources, translating into adverse nutrition outcomes, have been estimated by Jayachandran and Pande (2013) and Coffey, Spears, and Khera (2013). By carefully controlling for covariate confounders and using more objective measures of intrahousehold status, these studies were able to circumvent some of the between-household unobserved factors that could likely bias the aforementioned studies.

Using Demographic and Health Surveys (DHS) from around 25 countries, Jayachandran and Pande (2013) studied birth order effects in the India–Africa child height gap. They established that firstborn Indian children are taller than their African counterparts, but second- and third-born children and those born subsequently are statistically significantly shorter. Because the focus is on controlling for covariates that may disproportionately affect later-born children in India versus Africa, factors such as access to services (like health or sanitation), which do not vary much by birth order, are not found to confound the established birth order gradient. The authors accounted for India–Africa differences in mother’s age, child’s age, mortality selection among later-born children, mother’s predetermined health, and high fertility households, to establish that Indian second-born or third- and later-born children are shorter by 0.17 and 0.35 HAZ sd, respectively. Overarching explanations for the phenomena focus on cultural norms, such as an elder son preference, with the authors finding worse outcomes for later-born children if the first child is a son.

Coffey, Spears, and Khera (2013) used NFHS-3 data to compare nutritional outcomes of family members of differing rank, in a model that used only within-family variation in ranks. They found that, after controlling for a child’s gender, age in months, and the interaction of sex and age-in-month dummies, there is a negative and statistically significant effect of a mother’s rank on her child’s height – children of lower-ranked daughters-in-law are, on average, approximately 0.422 HAZ sd shorter than children of higher-ranked daughters-in-law. The authors complement their results by showing that lower-ranked daughters-in-law have lower status: controlling for age, lower-ranked daughters-in-law are significantly less likely than higher-ranked ones to report having a final say for decisions related to health, daily purchases, and spending money. Robust to relevant controls, lower-ranked daughters-in-law are about 0.4 BMI points lighter than higher-ranked daughters-in-law. Griffiths, Matthews, and Hinde (2002) did not find significant differences in the WAZ scores of children in households in which mothers-in-law and daughters-in-law reside together, when compared to households in which they do not; but compared with Coffey, Spears, and Khera (2013), their study unsatisfactorily accounts for between-household differences due to other factors.

Strong preference for sons in India also manifests in a positive association between male–female sex-ratios (MFR) and reductions in undernutrition for surviving girls. Likely mechanisms that explain this are girls being born
into families with weaker preference for sons and smaller families. Hu and Schlosser (2015) estimated that a 1 sd increase in state-level MFR is associated with a 3–4 percentage point reduction in the proportion of underweight and wasted girls. For Punjab, a state which saw the highest increase in MFR between 1992 and 2005, this effect size implies a 10 percentage point reduction in underweight girls.

Tables A.15.1a and A.15.2a clearly bring out the main comparisons of the pathways relevant to this quadrant. For child anthropometrics in Table A.15.1a, effects of maternal education (Imai et al. 2014) and (Bose 2011) do not appear to be strong, but these studies also employ a low level of confounder control. The same can be said of the effect of a woman’s education on her own health (Subramanian and Smith 2006) in Table A.15.2a. The impact of maternal autonomy was measured in a nonrobust manner (Shroff et al. 2009; Bose 2011; Imai et al. 2014) with regards to child nutritional status, and the evidence is scarce for adults. However, mostly, the effects of family composition due to intrahousehold rank both are measured robustly and are in the highest effect size bracket (Coffey, Spears, and Khera 2013; Jayachandran and Pande 2013). Interestingly, MFR at the state level is positively associated with a reduction in proportion of underweight girls (Hu and Schlosser 2015). As seen in Table A.15.2a, lower-ranked daughters-in-law have lower BMI (Coffey, Spears, and Khera 2013), but one study, Sabarwal et al. (2012), looked at the impact of husbands’ preferences for sons and the sex composition of the children in a household, but did not find statistically significant effects on the mother’s BMI status. However, a low level of confounder control is employed in this study (Table A.15.2a).

Water, sanitation, and adequate hygiene

Access to clean drinking water, the availability of toilets and sanitation, and the practice of good hygiene are deemed to be critical for nutrient absorption and utilization. Nutrient intake can translate into improved nutrition metrics only if the concerned population is not fraught with a high incidence of diarrheal disease, soil-transmitted helminth infection, and other gastrointestinal disorders.

Sanitation in India is a particular public health concern because over half of the population defecates in the open. About 60 percent of the approximately 1 billion people in the world who defecate in the open live in India (Spears 2012b). The link between open defecation and child stunting is well established. Using repeated cross-sections of DHS data on 65 countries, Spears (2013) estimated that changing the fraction of the population defecating in the open from 0 to 1 at the country level is associated with a linear decrease of 1.24 sd in HAZ. This result is robust to controlling for country fixed effects and time-varying factors, such as a country’s GDP, female literacy, immunization, and electrification. The density of open defecation – the number of people defecating in the open per square kilometer – is critical, too. In the same study, it is also established that the India–Africa child height gap would close by 30 percent if one controls for open defecation and by 83 percent if one controls for the density of open
defecation. Exploiting variation in open defecation within India, cross-sectional data from 112 Indian districts, part of the HUNGaMA survey, are used. Here, too, a 10 percent increase in open defecation is found to be associated with a 0.7 percentage point increase in stunting (Spears, Ghosh, and Cumming 2013).

While the association between open defecation and child anthropometrics (specifically stunting) is strong, randomized evaluations of toilet construction programs in India have failed to show statistically significant effects on malnutrition. For instance, a randomized control trial in Madhya Pradesh was run to assess the impact of subsidizing toilet construction and mobilizing communities to build toilets, under the framework of the Indian government’s “Total Sanitation Campaign (TSC)” (Patil et al. 2014). The study found no statistically significant differences either in child anthropometric outcomes or in diarrhea and other diseases between treatment and control villages. Reductions in men, women, and children defecating in the open were found to be small compared to increases in latrine availability. Another very similar experiment in Orissa also yielded similar results (Clasen et al. 2014). These authors also followed the framework of the government’s TSC and found no statistical differences in child anthropometrics in the villages “treated” by the toilet construction program. The only study that found favorable effects of the TSC is Spears (2012b), in which variation in the intensity of toilet construction at the district level is exploited, with district fixed effects and other controls in place. The study found that at its mean intensity, toilet construction under the program was associated with an increase of 0.2 HAZ sd. Rah et al. (2015) also found that having a toilet facility at home was associated with a lower likelihood of 16 percentage points for stunting among children, but the study analyzed a cross-section (NFHS-3) and included controls unlikely to fully account for selection into toilet ownership.

Why has toilet construction failed to show impacts on malnutrition despite such a strong relationship between open defecation and stunting? One reason could be that randomized evaluations with follow-up periods of 1.5–2 years are not long enough to detect changes in anthropometrics. While this is plausible, both of the RCTs under question also failed to find statistical reductions in diarrheal and other diseases, an outcome which should be observable within such a time frame. A more plausible explanation relates to the findings of the Sanitation Quality, Use, Access and Trends (SQUAT) survey, as summarized in Coffey et al. (2014), which argues that, for various cultural and religious reasons, there is a revealed preference for open defecation in India, and a large fraction of Indians defecate in the open despite having a working toilet at home. Moreover, the type of simple and affordable latrine that has been used to eliminate open defecation elsewhere in the world and the type which falls under the budget allocation of the Indian government’s TSC are not acceptable to most Indians. The features that SQUAT survey respondents describe in a sanitation system that they would use are about ten times the current budget allocation per toilet. While an important component of the TSC is community mobilization and inducing demand for toilets by discussing the ills of open defecation, on the ground Boisson et al. (2014) documented that implementation in the region of their evaluation
The malnutrition problem in India was well short of the goals, and none of the tools that have proved effective in community-led total sanitation programs were being employed. Therefore, in the Indian context, it is clear that toilet construction, at least of the pit latrine kind, is not the inverse of open defecation, and a better understanding of incentivizing toilet use is critical to the success of a policy of this type.

The effects of access to water and hygiene practices on malnutrition outcomes are under study in the Indian context. One notable study here used three cross-sectional data sets – NFHS 3, the HUNGaMA data set, and the Comprehensive Nutrition Survey in Maharashtra (CNSM) (Rah et al. 2015). In the analysis of all three surveys, household access to improved drinking water or piped water was not found to be a predictor of child stunting, and the authors did not observe any significant interactive effects between household access to improved water and sanitation on stunting. Effects of personal hygiene on child stunting were investigated in the HUNGaMA survey. Caregivers reported that the practice of washing hands with soap after defecation was associated with a 14 percentage point lower likelihood of stunting, and washing hands before eating food was associated with a 15 percentage point lower likelihood of stunting. Effects of personal hygiene on child stunting were found to be stronger in households with access to piped water and in households with access to a toilet facility.

Water quality, as measured by the presence of fertilizer agrochemicals in water, also bears a statistically significant, but small, association with child HAZ in the country. Using variations resulting from a combination of month of conception and across-state variation in planting seasons, it has been estimated that a 10 percent increase in the level of agrochemical toxins in water leads to a 0.014 sd reduction in HAZ (Brainerd and Menon 2014).

Table A.15.1a reiterates by way of its “Quadrant 4” papers that the most rigorous evaluations of toilet construction programs in India (Clasen et al. 2014; Coffey et al. 2014) have not found an effect on child malnutrition, and the effects of water and hygiene practices remain to be properly examined (Rah et al. 2015). Water quality is also associated with child malnutrition, and findings warrant future research on the topic (Brainerd and Menon 2014). As is evident in Table A.15.2a, none of the reviewed studies examined the impact of water, sanitation, or hygiene on adult malnutrition.

Agenda for future research

We include studies of varying quality in our review with the specific purpose of highlighting topic-wise gaps in the current state of the literature. Important avenues for future research emerge from our synthesis of the literature.

Overall, there is a lack of high-quality evidence to support the efficacy of pathways relevant to Quadrant 1, especially with regard to understanding better the connection between economic growth and malnutrition in India. Given the availability of at least some district-level anthropometric data from the DLHS surveys, it will be interesting to study the association between district-level growth and malnutrition. It is hard to measure district-level economic growth
in India, though some new types of data, like satellite imagery and night light data, might provide interesting solutions. Among Quadrant 2 papers, while there is some programmatic evidence regarding specific government programs that aid nutrition, in the Indian context, we have a poorer understanding of the general effects of food supplementation, dietary diversity, and own production of food. In studying the intrahousehold allocation of resources in Quadrant 3, only the effects of features of family composition, such as birth order and daughter-in-law rank, on malnutrition have been studied robustly. Much more can be done to leverage the women's autonomy and domestic violence modules of the NFHS datasets to yield more causal estimates of the relationship between women’s empowerment and child and maternal nutrition. This includes the possibility of quasi-experimental variation in women’s autonomy with respect to changes in India’s female inheritance laws and legislation on domestic violence. Lastly, a more detailed understanding of what works to create behavioral change around the usage of toilets in India will be critical to address a major roadblock to improving nutritional outcomes of Indians.
### Table A.15.1a The role of different pathways in the reduction of child stunting, underweight, and wasting in India: a summary of select effect sizes from the literature

<table>
<thead>
<tr>
<th>Effect size</th>
<th>Change in likelihood</th>
<th>Change in z-scores</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;0.10 sd.</td>
<td>0.10–0.30 sd.</td>
<td>&gt; 0.30 sd.</td>
</tr>
<tr>
<td></td>
<td>No/Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

(1) (2) (3)

### Quadrant 1 papers

State-level economic growth

- Subramanyam et al. (2011)
- Coffey, Chattopadhyay, and Gupta (2014)
- Food prices
- Vellakkal et al. (2015)

Household income

- Kanjilal et al. (2010)
- Bhagowalia, Headey, and Kadiyala (2012)
- Pathak and Singh (2011)

### Quadrant 2 papers

ICDS+ICDS treatments

- Lokshin et al. (2005)
- Kandpal (2011)
- Singh (2015)

(Continued)
<table>
<thead>
<tr>
<th>Quadrant 2 papers continued</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplementation and fortification</td>
<td>Semba et al. (2010)**L</td>
<td>Sazawal et al. (2010)**H</td>
<td>Kumar and Berkman (2015)**L</td>
</tr>
<tr>
<td></td>
<td>Bhandari et al. (2001)H</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDS</td>
<td>Tarozzi (2005)H</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quadrant 3 papers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother's education</td>
<td>Bose (2011)**L</td>
<td>Imai et al. (2014)**M</td>
<td></td>
</tr>
<tr>
<td>Mother's employment</td>
<td>Imai et al. (2014)**M</td>
<td>Bose (2011)**L</td>
<td>Shroff et al. (2009)**L</td>
</tr>
<tr>
<td>Domestic violence</td>
<td>Imai et al. (2014)M</td>
<td>Ackerson and Subramanian (2008)**M</td>
<td></td>
</tr>
<tr>
<td>State MFR</td>
<td>Hu and Schlosser (2015)**M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quadrant 4 papers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household has toilet</td>
<td>Clasen et al. (2014)H</td>
<td>Rah et al. (2015)**M</td>
<td>Rah et al. (2015)**M</td>
</tr>
<tr>
<td>Household has water</td>
<td>Patil et al. (2014)H</td>
<td>Spears (2012b)**M</td>
<td>Spears (2012b)**M</td>
</tr>
</tbody>
</table>
Quadrant 4 papers continued

<table>
<thead>
<tr>
<th>Water quality</th>
<th>Brainerd and Menon (2014)*M</th>
</tr>
</thead>
</table>

Hygiene

| Rah et al. (2015)**M |

Source: Authors' construction.

Note: The superscripts are L for low, M for medium, and H for high level of confounder control.

***, **, and * represent significance at the 10, 5, and 1 level, respectively.

### Table A.15.1b Units of measurement of predictor variables of interest in studies listed in Table A.15.1a

<table>
<thead>
<tr>
<th>Reference</th>
<th>Predictor variable</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quadrant 1 papers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State-level economic growth</td>
<td>Subramanyam et al. (2011); Coffey, Chattopadhyay, and Gupt (2014)*</td>
<td>SNDP per capita</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food prices</td>
<td>Vellakkal et al. (2015)</td>
<td>Change in rice consumption instrumented for with rice price increase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household (HH) income</td>
<td>Bhagowalia, Headey, and Kadiyala (2012); Kanjilal et al. (2010); Pathak and Singh (2011)</td>
<td>1st vs. 5th quintile of HH income</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Quadrant 2 papers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICDS</td>
<td>Lokshin et al. (2005); Kandpal (2011)</td>
<td>Presence of ICDS center in a village</td>
</tr>
<tr>
<td>ICDS</td>
<td>Jain (2015)</td>
<td>Receipt of daily ICDS supplementation</td>
</tr>
<tr>
<td>ICDS</td>
<td>Dubowitz et al. (2007)</td>
<td>Presence of Dular program in a village</td>
</tr>
<tr>
<td>Vitamin A supplementation</td>
<td>Semba et al. (2010)</td>
<td>Receipt of vitamin A supplementation</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>Quadrant 2 papers continued</th>
<th>Reference</th>
<th>Predictor variable</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iodized salt</td>
<td>Kumar and Berkmann (2015)</td>
<td>Usage of iodized salt</td>
<td>Binary</td>
</tr>
<tr>
<td>Cereal and suppl.+nut counseling</td>
<td>Bhandari et al. (2001)</td>
<td>“Treatment” infants</td>
<td>Binary</td>
</tr>
<tr>
<td>Fortified milk</td>
<td>Sazawal et al. (2010)</td>
<td>“Treatment” children</td>
<td>Binary</td>
</tr>
<tr>
<td>Dietary diversity</td>
<td>Bhagowalia, Headey, and Kadiyala (2012); Menon et al. (2015)</td>
<td>Dietary div. score/ budget share of FGs</td>
<td>Continuous</td>
</tr>
<tr>
<td>Consumption from self-production</td>
<td>Parasuraman and Rajaretnam (2011)</td>
<td>Proportion of food consumption from own production</td>
<td>Continuous</td>
</tr>
<tr>
<td>PDS</td>
<td>Tarozzi (2005)</td>
<td>No. of months spent with lower subsidy</td>
<td>Continuous</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quadrant 3 papers</th>
<th>Reference</th>
<th>Predictor variable</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal education</td>
<td>Imai et al. (2014)</td>
<td>Ratio of maternal to paternal education</td>
<td>Continuous</td>
</tr>
<tr>
<td>Maternal education</td>
<td>Bose (2011)</td>
<td>Years of education</td>
<td>Continuous</td>
</tr>
<tr>
<td>Maternal employment</td>
<td>Bose (2011)</td>
<td>Employment status: employed</td>
<td>Binary</td>
</tr>
<tr>
<td>Maternal autonomy</td>
<td>Shroff et al. (2009); Imai et al. (2014)</td>
<td>Needs permission to go to market</td>
<td>Binary</td>
</tr>
<tr>
<td>Maternal autonomy</td>
<td>Shroff et al. (2009)</td>
<td>Can set aside money w/o permission</td>
<td>Binary</td>
</tr>
<tr>
<td>Maternal autonomy</td>
<td>Bose (2011)</td>
<td>Autonomy Index</td>
<td>Continuous</td>
</tr>
<tr>
<td>Domestic violence</td>
<td>Ackerson and Subramanian (2008)</td>
<td>Multiple instances of violence in past year</td>
<td>Binary</td>
</tr>
<tr>
<td>Domestic violence</td>
<td>Imai et al. (2014)</td>
<td>Wife believes domestic violence justified</td>
<td>Binary</td>
</tr>
<tr>
<td>Family composition</td>
<td>Griffiths, Matthews, and Hinde (2002)</td>
<td>Households in which mother and daughters-in-law co-reside</td>
<td>Binary</td>
</tr>
<tr>
<td>Family composition</td>
<td>Hu and Schlosser (2015)</td>
<td>MFR interacted with female dummy</td>
<td>Continuous</td>
</tr>
<tr>
<td>Quadrant 4 papers</td>
<td>Reference</td>
<td>Predictor variable</td>
<td>Unit</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------</td>
<td>--------------------</td>
<td>------</td>
</tr>
<tr>
<td>HH has toilets</td>
<td>Clasen et al. (2014); Patil et al. (2014)</td>
<td>“Treatment” TSC villages</td>
<td>Binary</td>
</tr>
<tr>
<td>HH has toilets</td>
<td>Rah et al. (2015)</td>
<td>HH has toilet</td>
<td>Binary</td>
</tr>
<tr>
<td>HH has toilets</td>
<td>Spears (2012b)</td>
<td>TSC toilets per capita(^1)</td>
<td>Continuous</td>
</tr>
<tr>
<td>HH has water</td>
<td>Rah et al. (2015)</td>
<td>HH has improved/ piped water source</td>
<td>Binary</td>
</tr>
<tr>
<td>Water quality</td>
<td>Brainerd and Menon (2014)</td>
<td>Presence of fertilizer agrochemicals</td>
<td>Continuous</td>
</tr>
<tr>
<td>Hygiene</td>
<td>Rah et al. (2015)</td>
<td>Caregiver washes hands</td>
<td>Binary</td>
</tr>
</tbody>
</table>

Source: Authors’ construction.

Note: Unless otherwise specified, for the binary variables, the reference group is the negation of the predictor variable mentioned in the table.

\(^1\) However, the effect reported is the coefficient times the mean intensity of TSC toilets per district.

---

**Table A.15.2a** The role of different pathways in the reduction of adult underweight (low BMI) in India: a summary of select effect sizes from the literature

<table>
<thead>
<tr>
<th>Change in z-scores</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10 pp.</td>
<td>&lt;0.10 points</td>
</tr>
<tr>
<td>&gt;10–30 pp.</td>
<td>0.10–0.30 points</td>
</tr>
<tr>
<td>&gt;30 pp.</td>
<td>&gt;0.30 points</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Statistical Significance</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No/Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quadrant 1 papers</th>
<th>Nature of employment</th>
<th>Subramanian and Smith (2006)(^k)</th>
<th>Headey, Chiu, and Kadiyala (2012)***(^k)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Quadrant 2 papers</th>
<th>Consumption from self-production</th>
<th>Parasuraman and Rajaretanam (2011)(^M)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Quadrant 3 papers</th>
<th>Education</th>
<th>Subramanian and Smith (2006)(^k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic violence</td>
<td>Ackerson and Subramanian (2008)**(M)</td>
<td></td>
</tr>
<tr>
<td>Family composition</td>
<td>Sabarwal et al. (2012)(^k)</td>
<td>Coffey, Spears and Khera (2013)(^H)</td>
</tr>
</tbody>
</table>

Source: Authors’ construction.

Note: The superscripts are L for low, M for medium, and H for high level of confounder control.

***, **, and * represent significance at the 10, 5, and 1 level, respectively.
Table A.15.2b Units of measurement of predictor variables of interest in studies listed in Table A.15.2a

<table>
<thead>
<tr>
<th>Quadrant 1 papers</th>
<th>Reference</th>
<th>Predictor Variable</th>
<th>Unit</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Quadrant 2 papers</th>
<th>Reference</th>
<th>Predictor Variable</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption from self-production</td>
<td>Parasuraman and Rajaretnam (2011)</td>
<td>Proportion of food consumption from own production</td>
<td>Continuous</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quadrant 3 papers</th>
<th>Reference</th>
<th>Predictor Variable</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woman's education</td>
<td>Subramanian and Smith (2006)</td>
<td>Woman has 6–8 years of education (effect size in 2A for 1 year of education)</td>
<td>Binary (reference category &gt;15 years of education)</td>
</tr>
<tr>
<td>Domestic violence</td>
<td>Ackerson and Subramanian (2008)</td>
<td>Multiple instances of violence in past year</td>
<td>Binary</td>
</tr>
<tr>
<td>Family composition</td>
<td>Sabarwal et al. (2012)</td>
<td>Couple has only girl children</td>
<td>Binary (couple has only boy children)</td>
</tr>
</tbody>
</table>

Source: Authors' construction.

Notes

1 The “Asian Enigma,” when first flagged, highlighted high rates of child malnutrition in South Asia, as compared to sub-Saharan Africa, despite comparable purchasing powers at the time in the both regions (Ramalingaswamy, Jonsson, and Rohde 1996).

2 The fourth round of the District Level Household and Facility Survey (DLHS-4) was made available recently at http://iipsindia.org/dlhs4.htm, and reports from the National Family and Health Survey (NFHS-4) on state-level aggregates for Phase 1 states were also released in the third week of January 2016.

3 UNICEF’s RSOC, which measured and weighed 90,000 children and 28,000 teenage girls, was conducted in 29 states and union territories in 2013 and 2014. While the data and report have not yet been formally released, media reports based on the data (Economist 2015; Rowlatt 2015; Rukminini S 2015) have come into focus since early July 2016.

4 The Lancet Nutrition Series Framework (Black et al. 2013) extends the UNICEF framework by providing a conceptual mapping of the programmatic and policy interventions for achieving improved nutrition. It is an operational guide rather than a behavioral representation of the determinants of nutrition outcomes.
5 Hereafter, HAZ=height-for-age z-scores, WAZ=weight-for-age z-scores, and WHZ=
weight-for-height z-scores. Stunting, underweight, and wasting prevalence refers to the
fraction of children under -2 sd of HAZ, WAZ, and WHZ, respectively.
6 We also include only those studies that utilize data collected in this period.
8 For constructing the Normalized Child Malnutrition Index (NCMI), three indicators
of child malnutrition — that is, the fraction stunted, wasted, and underweight — in a state
were taken and normalized according the formula
\[
\text{Normalized indicator} = \frac{\text{actual value} - \text{minimum value}}{\text{maximum value} - \text{minimum value}},
\]
and then combined using a simple average of the normalized indicators. The Normalized
Adult Malnutrition Index (NAMI) was constructed similarly, using the fraction of “thin”
(BMI<18.5) men and women.
9 Children aged 3–6 are generally fed at the center, and younger children receive take-home
rations that last anywhere between a week and a month. ICDS centers are supposed to
provide food for 25 days a month, and figures from the NFHS show that the program
provides approximately 300 calories and 8–10 grams of protein to children aged 0–72
months on a daily basis (Chalasani 2012).
10 The treatment involves a payment of 100 rupees for each child whose weight-for-age
grade improved, minus the number for whom it declined within a three-month period.
11 The treatment group received milk fortified with essential micronutrients (zinc and iron),
and the control group received equal doses of regular milk.
12 See Jensen and Miller (2011 ) for analysis of the nutrition effects of food price subsidies
in China.
13 Daughters-in-law married to younger brothers in a joint family setup.
14 Authors suggest that the reluctance of Indians to defecate in toilets in or close to their
homes, especially when emptying of pit latrines is involved, is perhaps related to concepts
of purity and pollution, uniquely tied to the Hindu caste system in India.

References

tion among Women and Children in India.” American Journal of Epidemiology 167 (10):
1188–96.

ality and Gender Bias in Rural Nutrition: Empirical Evidence from South India.” Social

ages in India. Insights from a Nationally Representative Survey.” IFPRI Discussion Paper
01195, International Food Policy Research Institute (IFPRI), Washington, DC.

Supplementation with Encouragement to Feed It to Infants from 4 to 12 Months of Age

“Maternal and Child Undernutrition and Overweight in Low-income and Middle-income

2014. “Promoting Latrine Construction and Use in Rural Villages Practicing Open Def-
ecation: Process Evaluation in Connection with a Randomised Controlled Trial in Orissa,
India.” BMC Research Notes 7: 486.


The malnutrition problem in India


