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Agriculture, Income, and Nutrition Linkages in India

Insights from a Nationally Representative Survey

Priya Bhagowalia

Derek Headey

Suneetha Kadiyala

Poverty, Health, and Nutrition Division

Development Strategy and Governance Division

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AUTHORS

Priya Bhagowalia, Ambedkar University, Delhi
Associate Professor of Economics, School of Liberal Studies

Derek Headey, International Food Policy Research Institute
Research Fellow, Development Strategy and Governance Division

Suneetha Kadiyala, International Food Policy Research Institute
Research Fellow, Poverty, Health, and Nutrition Division

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ABSTRACT

India contains the majority of the world's malnourished children, yet malnutrition has declined only very slowly in recent years, despite rapid economic growth and apparent improvements in food security. Understanding and addressing the causes of malnutrition in India is therefore a critically important objective. Most research on these issues has focused on nutrition-specific interventions rather than the broader economic processes that also influence nutritional change. In light of this knowledge gap, this paper focuses on linkages between nutrition and household incomes, as well as agricultural production. To do so, we use a relatively recent nationally representative household survey from India, the 2004/05 India Human Development Survey. First we explore the relationships between household income and anthropometric indicators, controlling for a range of other determinants of nutrition. We also test hypotheses related to the perceived importance of agricultural income and production conditions, such as irrigation and ownership of land and livestock. Our results suggest that the income gradient for undernutrition is indeed quite weak, although non-income determinants such as female secondary education, access to safe water and sanitation facilities, antenatal checkups, and children's vaccinations all have significant effects on child nutrition. We also find some evidence that agricultural production conditions—particularly irrigation and ownership of livestock—substantially influence household dietary diversity. The findings imply that income growth alone will likely have only modest impacts on malnutrition unless it is accompanied by improved health and education outcomes. For agriculture, the results also suggest some important nutritional entry points in terms of irrigation, crop diversification, and livestock ownership.

Keywords: malnutrition, household incomes, agricultural production, India

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1. INTRODUCTION

The prevalence of undernutrition in India has long been thought of as enigmatically high, given the region's income levels and the success of the Green Revolution. However, in recent years the Indian enigma has become even more enigmatic. From 1998/99 to 2005/06, average Indian gross domestic product (GDP) per capita grew at unprecedented rates, expanding by 40 percent in just seven years. Yet over the same period, according to the National Family Health Surveys (NFHS), the proportion of Indian children that were stunted declined only from 51.0 percent to 44.9 percent, and the proportion that were underweight declined from 42.7 percent to 40.4 percent. This sluggish nutritional performance in the face of strong economic growth has raised the possibility that undernutrition in India is in some sense disconnected from economic growth in general and perhaps from agricultural growth in particular.

While these disconnects remain a possibility, the scope for documenting them remains rather weak. In general, the kinds of surveys that measure anthropometric data do not measure many economic variables, and the kinds of surveys that measure economic variables typically do not measure anthropometrics. As a prime instance of the former, the aforementioned NFHS surveys measure an index of household wealth but not income, consumption, or agricultural production variables. And as an instance of the latter, the National Sample Survey measures expenditure and food consumption (and hence calorie intake) but does not measure anthropometrics.

These data disconnects mean that existing evidence on the relationship between income, agricultural production, and nutrition is largely unsatisfactory. For example, a number of studies have shown that the Demographic and Health Surveys (DHS) program wealth index strongly explains anthropometric outcomes (Headey, Chiu, and Kadiyala 2012), and Headey (2011) showed that the cross-sectional relationship between the DHS wealth index and stunting in India is standard relative to other countries. Subramanyam et al. (2011) tested whether economic growth at the state level predicts improvements in childhood undernutrition across the three rounds of the NFHS (1992/93, 1998/99, and 2005/06), while Headey, Chiu, and Kadiyala (2012) performed a similar exercise but also included agricultural and nonagricultural growth rates. Both studies were constrained by small samples, although both found some effects of income growth on undernutrition. However, Headey, Chiu, and Kadiyala (2012) found only limited evidence that agricultural growth matters (in the case of stunting), and they also documented examples of specific states where agricultural growth is manifestly not accompanied by improvements in undernutrition (such as in Gujarat and Madhya Pradesh). More indirect work has looked at the effect of household wealth on children's dietary diversity (Headey, Chiu, and Kadiyala 2012) and the effect of dietary diversity on nutrition outcomes (Aguayo et al. 2011). Perhaps the only existing microeconomic research linking nutrition to household expenditure, agricultural production, and food consumption is work on the Young Lives panel for Andhra Pradesh (Himaz 2009). That study confirmed the importance of dietary diversity and household wealth, and also used the panel nature of the data to find that the occurrence of drought increased the chances of stunting and underweight by around 6 percent (Himaz 2009). However, the sample was representative only for rural areas in Andhra Pradesh.

In light of these shortcomings in existing datasets, this paper utilizes a recent nationally representative survey—the 2004/05 India Human and Development Survey (known as IHDS 2005) (Desai et al. 2008)—that contains both standard economic variables, including those pertaining to agricultural production and food consumption, and anthropometric indicators. The objective of this paper is threefold.

First, we use IHDS 2005 to explore relationships between household income and anthropometric indicators, controlling for a range of other determinants of nutrition. As noted above, there is some existing work in the Indian context on this issue, but only with asset-based proxies for wealth or only with subnational data. In this paper we aim to explore the long-run (that is, cross-sectional) income–nutrition relationship and thereby provide a basis for comparison with existing estimates from other countries, sourced from Smith and Haddad (2002). We also disaggregate income–nutrition relationships by rural and urban households, by agricultural and nonagricultural households, and by regions.

Second, we explore the linkages between agricultural variables and nutrition, including agricultural income, irrigation, and landownership. Here we are implicitly testing a number of hypotheses related to the perceived importance of agricultural assets in determining rural incomes. Also, irrigation might play multiple roles, both positive and negative. On the positive side, irrigation might expand incomes and also reduce income volatility. Irrigation might also provide a source of relatively clean drinking water. However, irrigation also tends to increase the prevalence of malaria, to which the nutritional status of young children and pregnant mothers is very vulnerable.

Third, we explore the linkages between agricultural production, household dietary diversity, and nutrition. As noted above, previous research has looked at the effect of household wealth on children's dietary diversity (Headey, Chiu, and Kadiyala 2012) and the effect of dietary diversity on nutrition outcomes (Aguayo et al. 2011). However, it remains an open question as to what role agricultural production plays in dietary diversity. Some existing research has found that landless rural households essentially possess the same dietary patterns as farm households (Sharma 2006). This suggests that adequate access to markets (in terms of purchasing power and physical access) suffices to ensure that dietary patterns are not solely determined by own-production. Recent research from the Young Lives Andhra Pradesh panel tends to confirm the limited importance of own-production on diets in the Indian context, in that children in farm households not specialized in food production tended to have more diverse diets (Galab and Reddy 2011). While IHDS data used in this paper do not have the requisite information on the individual dietary diversity of children, we can examine dietary diversity at the household level.

Given these objectives, the remainder of the paper is structured as follows. Section 2 describes the IHDS 2005 data and various measurement and estimation issues. Section 3 looks at the income–nutrition relationship using both ordinary least squares (OLS) and instrumental variables approaches, while controlling for a range of other determinants, including agricultural variables. Section 4 disaggregates income–nutrition relationships by household type. Section 5 looks at the determinants of household dietary diversity. Section 6 concludes.

2. DATA AND METHODS

Introduction to the India Human Development Survey 2005

The 2004/05 India Human Development Survey, known as IHDS 2005 (Desai et al. 2008), is a nationally representative, multi-topic survey of 41,554 households in 1,503 villages and 971 urban neighborhoods across India, with the exception of the islands of Lakshadweep, Andaman, and Nicobar. The sample extends to 384 out of 593 districts identified in the 2001 census, and covers 1,503 villages and 971 urban blocks located in 276 towns and cities.

Villages and urban blocks (comprising 150–200 households) formed the primary sampling unit (PSU), but the selection of PSUs differed across urban and rural areas. In order to draw a random sample of urban households, all urban areas in a state were listed in the order of size, with the number of blocks drawn from each urban area allocated based on probability proportional to size. Once the numbers of blocks for each urban area were determined, the enumeration blocks were selected randomly with help from the registrar general of India. From these census enumeration blocks of about 150–200 households, a complete household listing was conducted, and a sample of 15 households was selected per block. For sampling purposes, some smaller states were combined with nearby larger states. About half of the rural sample is made up of households that were interviewed initially by the National Council of Applied Economic Research in 1993/94 in a survey titled *Human Development Profile of India* (HDPI). The other half of the samples were drawn from districts surveyed in HDPI as well as from the districts located in the states and union territories not covered in HDPI (Desai et al. 2009).

Unlike most health or consumption expenditure surveys, the IHDS combines information on anthropometric measurements of children, expenditure on food consumption, and household income. The survey also contains household- and individual-level data on education, employment, economic status, marriage, fertility, gender relations, and social capital. Additional village, school, and medical facility interviews are also available. The survey also reports price, quantity, and value information for consumption over a 30-day recall period for food items such as rice, cereals, pulses, vegetables, fruits, and animal products. In addition, it records whether the consumption is from home-grown stock or purchased from the public distribution system.

Another advantage of the IHDS that makes it suited to studying the linkages between agriculture and nutrition is that it includes data on landownership; farming practices; crop diversity; and expenditure on animals, labor, equipment, and loans. Anthropometric information is reported for all ever-married women aged 15–49 years, and children aged 0–5 and 8–11 years. However, a large number of children (46 percent) in the sample were not measured or have measurements that are implausible. It appears the main reason for the omission of many children was that they were not at home at the time of surveying. Hence a significant amount of data cleaning was involved, and our sample is obviously restricted to the subsample of children for whom we have all pertinent indicators. Even so, the sample is still large and appears to be nationally representative in that undernutrition prevalence rates closely match those of the National Family Health Survey (NFHS)–3. Overall, our sample comprises 34 states, 570 districts, and a total of 19,000 children from birth to 5 years old.

Indicators of the Determinants of Undernutrition

Following the extended model of care (Engle, Menon, and Haddad 1996), we examine the effect of underlying determinants of health. These include resources for food security, caregiver resources and knowledge, access to healthcare, sanitation, and safety of the water supply. We explain below how each of these is measured in our analysis, while Table 2.1 provides an overview of the variables used and their definitions.

Resources for food security are measured by economic status and food production. IHDS was one of the first developing-country surveys to collect detailed income data. More than 50 different income sources were queried and categorized into eight major income types and a total income variable (denoted as "income"). All are household-level variables (Desai et al. 2008). The variable "income" is summed across more than 50 separate components, including wages and salaries, net farm income, family business net income, property income, remittances, public benefits, and pension income. Farm income is computed from crop production and prices, use of crop residues, animal ownership, home-produced animal and crop products, expenses for a variety of farm inputs, and agricultural rents paid and received. Wage and salary incomes are summed across all jobs of all individuals in the household, and annual totals are estimated using the report of days worked for workers paid daily wages or monthly salaries. All of these components are aggregated to estimate total income of the household. This income variable is then used to generate quintiles of income, which are used as an explanatory variable in our regressions. One advantage of using quintiles is that our results may be compared with those of other surveys, such as the NFHS, that use wealth quintiles; another is that the use of quintiles allows for nonlinearities.1 However, we also estimate income effect in logarithmic form, which we report in the appendix.

We use the number of crops cultivated by a household as a proxy for food production. This variable is used to study the pathways through which agriculture can interact with dietary diversity (explained below) and child nutrition. We also considered measuring calories at the household level, but this proved difficult due to inadequate data on food consumption in the household.

Caregiver resources and knowledge are modeled in terms of maternal education, maternal age, and gender equality. Evidence on the effect of parental education on child height has been varied. While some studies have concluded that there is little or no effect of maternal education on child nutrition (Behrman and Wolfe 1987), others have found significant positive effects of maternal education on child height (Cochrane, Leslie, and O'Hara 1982; Thomas, Strauss, and Henriques 1991). Previous estimates have suggested that a mother's education increases a child's height by about 0.5 percent with every additional year of education (Thomas, Strauss, and Henriques 1991). Similar results were also found by other studies (see, for example, Christiaensen and Alderman 2001), including in India (Moestu 2005). More educated women are better able to acquire and process information about healthcare facilities, interact effectively with healthcare providers, comply with treatment recommendations, and keep their living environments clean. We measure maternal education as dummy variables for primary schooling and secondary schooling, with no education as the reference category.

Gender inequality is modeled in terms of women's decisionmaking power. The autonomy and control women have over resources affects their ability to care for themselves and their children (Ramalingaswami, Jonsson, and Rohde 1996). We use an additive index of relative decisionmaking power to measure gender inequality. This index denotes the number of decisions that are made by the woman. The index is based on seven questions: who decides what to cook, household purchases of expensive items, how many children to have, and how a sick child should be cared for; if permission is needed to go to the local health center or the *kirana* (grocery) store; and who shops for food and vegetables. These questions are similar to those posed in the NFHS-3.

Resources for health, or the health environment of the household, are measured in terms of healthcare availability and access to safe water and sanitation. Healthcare availability is captured by caring practices for the mother such as prenatal and birthing care, which are crucial for child nutrition (Smith, Ruel, and Ndiaye 2004). Prenatal care for women involves tetanus immunizations, prevention of anemia, and dissemination of knowledge about safe caring practices for women and children. Health-seeking behaviors for women are measured by a dummy variable that indicates whether the woman had antenatal checkups during at least one of the last two pregnancies.

[1] We restrict our analysis to those households whose income is greater than or equal to zero.

Table 2.1—Summary statistics for determinants of child nutrition in the IHDS data

Economic determinant	Definition	N	Mean	Std. dev.	Minimum	Maximum
Income quintile	Highest income quintile is omitted category	18,805	46,261.7	75,893	0	6,520,261
Demographic characteristics						
Child age category (0–1 year)	1 if child is 0–1 year, 0 otherwise	19,000	0.28	0.45	0	1
Child age category (2 years)	1 if child is 2 years, 0 otherwise	19,000	0.18	0.38	0	1
Child age category (3 years)	1 if child is 3 years , 0 otherwise	19,000	0.20	0.40	0	1
Child age category (> 3 years)	1 if child is more than 3 years of age, 0 otherwise	19,000	0.34	0.47	0	1
Child sex	0 if girl, 1 if boy	19,000	0.52	0.50	0	1
Household size	Number of adults and children in the household	19,000	7.01	3.10	2	38
Adults	Number of adults in the household	19,000	3.26	1.68	0	18
Teens	Number of teens in the household	19,000	0.58	0.93	0	8
Children	Number of children in the household	19,000	3.17	1.73	1	17
Mother's age	Mother's age at the time of survey	18,643	27.48	5.72	15	63
Socioeconomic determinants						
No education (omitted category)	1 if woman had no education at all, 0 otherwise	18,544	0.51	0.50	0	1
Woman's primary education	1 if woman completed primary school, 0 otherwise	18,544	0.14	0.35	0	1
Woman's secondary education	1 if woman completed secondary school, 0 otherwise	18,544	0.35	0.48	0	1
Woman's decisionmaking power	Additive index, number of decisions made by the woman	19,000	4.84	1.61	0	7
Household health environment						
Other water source (omitted category)	1 if household's waster source is hand pump, river, pond, truck, bottled water, rainwater, or other; 0 otherwise	19,000	0.43	0.49	0	1
Well water	1 if household has access to water from tubewell, covered well, or open well; 0 otherwise	19,000	0.26	0.44	0	1
Piped water	1 if household has access to piped water, 0 otherwise	19,000	0.31	0.46	0	1
No toilet (omitted category)	1 if household has no toilet	18,904	0.69	0.46	0	1
Traditional pit latrine	1 if household has access to a traditional pit latrine, 0 otherwise	18,904	0.10	0.30	0	1
Ventilated pit latrine	1 if household has access to a ventilated, improved pit latrine, 0 otherwise	18,904	0.05	0.21	0	1
Flush toilet	1 if household has access to flush toilet, 0 otherwise	18,904	0.16	0.37	0	1

Table 2.1—Continued

Economic determinant	Definition	N	Mean	Std. dev.	Minimum	Maximum
Health-seeking behaviors for children and mothers						
Not ill (omitted category)	1 if not ill, 0 otherwise	19,000	0.68	0.46	0	1
Treatment for fever, cough, diarrhea	1 if treatment given for fever, cough, and diarrhea; 0 otherwise	19,000	0.01	0.12	0	1
Ill, no treatment	1 if ill but no treatment given for fever, cough, and diarrhea; 0 otherwise	19,000	0.30	0.46	0	1
Antenatal checkups for at least 1 pregnancy	1 if antenatal checkups for at least 1 of the last 2 pregnancies, 0 otherwise	16,560	0.74	0.44	0	1
No vaccination	1 if no vaccination is given for BCG, DPT, measles, polio; 0 otherwise	12,436	0.03	0.18	0	1
At least 1 vaccination given	1 if at least 1 vaccination is given for BCG, DPT, measles, polio; 0 otherwise	12,436	0.49	0.50	0	1
All vaccinations given (BCG, DPT, measles, polio)	1 if all vaccinations are given for BCG, DPT, measles, polio; 0 otherwise	12,436	0.47	0.50	0	1
Dietary diversity						
Dietary diversity score	Number of food groups consumed by the household	19,000	6.95	2.64	0	13
Cereals	Cereals share in food budget	18,982	0.37	0.14	0	0.98
Pulses	Pulses share in food budget	18,982	0.06	0.04	0	0.62
Meat	Meat share in food budget	18,982	0.06	0.07	0	0.90
Eggs	Eggs share in food budget	18,982	0.01	0.02	0	0.43
Milk	Milk share in food budget	18,982	0.11	0.10	0	0.68
Vegetables	Vegetables share in food budget	18,982	0.12	0.06	0	0.83
Fruits	Fruits share in food budget	18,982	0.02	0.04	0	0.62
Regions						
Central	Madhya Pradesh, Chhattisgarh					
East	Bihar, West Bengal, Jharkhand, Orissa					
North	Uttar Pradesh, Delhi, Uttaranchal, Jammu and Kashmir, Haryana, Punjab, Himachal Pradesh, Chandigarh					
Northeast (omitted category)	Arunachal Pradesh, Nagaland, Meghalaya, Tripura, Assam, Manipur, Sikkim, Mizoram					
South	Andhra Pradesh, Kerala, Tamil Nadu, Pondicherry, Karnataka					
West	Goa, Maharashtra, Dadra and Nagar Haveli, Daman and Diu, Gujarat, Rajasthan					

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Notes: BCG = tuberculosis vaccine; DPT = diphtheria, pertussis, tetanus vaccine.

Access to healthcare for children also involves measures to control infectious diseases in young children, especially diarrhea, which is considered to be a major killer of children under the age of 5 years (WHO 2004). Dummy variables are also constructed to capture health-seeking behavior for children: whether a child had fever, cough, or diarrhea in the month preceding the survey; whether a child was ill and treated for these symptoms; or whether a child was ill but did not receive any treatment. Vaccination for polio; diphtheria, pertussis, and tetanus (DPT); measles; and tuberculosis (bacillus Calmette-Guérin, or BCG vaccine) was also measured by dummy variables. The recommended doses of these vaccines are given right after birth (BCG); at 6, 10, and 14 weeks (DPT and polio); and at 12–15 months (measles). We use no vaccination as the reference category and include a dummy if at least one of the four vaccines is given, and a dummy if all vaccines are given to the child.

Access to safe water is denoted by a dummy variable that takes a value of 1 if the household's usual source of water is a covered, open, or tubewell. Another dummy variable is used to denote access to piped water. All other water sources—hand pump, river, pond, truck, bottled water, rainwater, or other—are the reference category. Sanitation is also indicated by dummies denoting no toilet; access to a traditional toilet; access to a ventilated, improved toilet; and access to a flush toilet. A set of regional dummies is also used to capture geographic variation among households.

Measurement of Undernutrition

The dependent variables in this study reflect the nutritional status of children, which is measured by their height-for-age Z-score (HAZ) and weight-for-height Z-score (WHZ). The HAZ is an indicator of chronic malnutrition, whereas the WHZ is indicative of more recent short-term deprivation. We chose to use these two indicators rather than weight-for-age, because weight-for-age is a function of these two indicators. Moreover, we note that stunting is our preferred measure, since most of the indicators pertain to accumulated nutrition problems that are seen in chronic malnutrition. The Z-scores are computed relative to a healthy population as advocated by the World Health Organization (WHO 2008) using the *igrowup* package of Stata programs to convert the observed weight, height, and age of any given child into a Z-score. These Z-scores are further used to compute prevalence of stunting, wasting, and underweight. A child is considered to be stunted (wasted) if the HAZ (WHZ) is two standard deviations below the median Z-score.

This study also uses dietary diversity as an indicator of child's dietary intake and its impact on nutrition. Dietary diversity is measured in two ways. The first measure of dietary diversity is the unweighted sum of the number of food items consumed by the household in last month, and the second is share of food expenditure devoted to cereals (rice, wheat, coarse grains) versus non-cereals. The main advantage of using dietary diversity scores is the ease with which these data can be collected and used in the absence of data on calorie or nutrient intakes. Dietary diversity has also been shown to be correlated with calorie adequacy and overall dietary adequacy (Kennedy et al. 2007).

Ideally, dietary diversity should be computed at the individual level and based on information for the last 24 hours. The disadvantage of our measure is that recall periods for the household are 30 days. Also, it is at best a crude approximation for inferring the dietary adequacy of children. Despite these limitations, however, we believe that our measures of dietary diversity offer some insights into the food security of the household, which is most likely a necessary precondition for ensuring food security for individuals.

3. AGGREGATE INCOME-NUTRITION LINKAGES

The effects of underlying determinants of nutrition on HAZ and WHZ for the entire sample are shown in Table 3.1. As expected, income has a significant effect on HAZ, but the relationship is nonlinear: Only the richest quintile has significantly greater HAZ results (around half a standard deviation) relative to the poorest. This suggests that income growth might indeed have little effect on stunting unless it involves moving to a much higher level of income.

The results are similar for WHZ—an indicator of acute malnutrition—since only the top two quintiles have significantly better outcomes than the poorest quintile. This is probably to be expected in that one would generally expect wasting to take place only in very food-insecure households or households affected by illness or other idiosyncratic factors.

As for other results, we find that the age of the child matters. Relative to the reference category of children aged birth to 1 year, the age group of two years is associated with lower HAZ. This is not surprising, because linear growth starts to falter from birth to age 2 before stabilizing (Ruel et al. 1998; Adair 1999; Victora et al. 2010). From around the sixth month of life onward, growth is affected by the availability of a diverse diet and the frequency of feeding after weaning. Hence dietary quality could play a significant role in explaining the faltering of growth from six months to around two years of age.

HAZ and WHZ do not seem to vary for boys and girls, although household size has a negative effect on both indicators. Women's secondary education is significantly correlated with height but not weight. HAZ of children whose mothers have completed secondary education are 0.25 Z-scores higher than that of children whose mothers have no education. This is quite a large point estimate, but it is not very precisely estimated. The result is also consistent with most other nutrition studies, which find that secondary or higher education matters, but not primary education. Mother's age has a significant positive impact on HAZ but not WHZ.

Women's decisionmaking power has a negative impact on HAZ and WHZ, although it is statistically significant only for the latter. This somewhat surprising effect might be attributed to the construction of the index, since the questions asked are reflective of general decisionmaking rather than anything specific to maternal or child nutrition. However, Smith, Ruel, and Ndiaye (2004) also found a weak and negative relationship between decisionmaking and HAZ in rural areas of Latin America and the Caribbean, which they attributed to a negative association between decisionmaking and breast-feeding. It could also be that decisionmaking power is partly captured by women's education or by income effects.

The household environment in terms of access to water has a weak correlation with HAZ and WHZ. WHZ is negatively associated with access to water from a covered, open, or tubewell, which is consistent with the findings of earlier literature, raising concerns about the quality and contamination of groundwater. Relative to having no toilets, access to a traditional or flush toilet is associated with higher HAZ and WHZ. These results suggest that access to safe water and sanitation facilities might play an important role in the growth of young children, although the definition and measurement of improved water and sanitation is quite difficult (Smith, Ruel, and Ndiaye 2004).

Health-seeking behaviors for children show mixed results. With regard to illness, being treated for illness appears quite surprisingly to be associated with lower HAZ, with a coefficient that is similar to that of being ill and not being treated. We suspect that this result has more to do with selection biases, since children may be treated only if the illness is more severe. More encouragingly, antenatal checkups have a large and highly significant effect on HAZ, as do vaccinations. Interestingly, none of the regional dummies are significant, although it is quite normal to see that household factors do a better job of explaining nutrition outcomes than regional factors, since there is relatively little spatial clustering of nutrition (Fenn, Morris, and Frost 2004).

Table 3.1—Effects of income, water, sanitation, and health on nutrition outcomes

	HAZ	WHZ
2nd quintile	-0.10	-0.03
3rd quintile	0.01	0.06
4th quintile	0.10	0.17*
5th quintile	0.43***	0.22**
Child age category (2 years)	-0.59***	-0.35***
Child age category (3 years)	0.21	-0.07
Child age category (>3 years)	1.50***	-0.12
Child sex	0.08	-0.03
Household size	-0.02	-0.02*
Women's education primary	0.13	0.01
Women's education secondary	0.25***	-0.10
Women's decisionmaking power	-0.02	-0.03*
Mother's age	0.02**	-0.00
Central	-0.14	0.43
East	0.11	0.44
North	-0.09	0.41
South	0.03	0.20
West	0.01	0.10
Well water	0.02	-0.06
Piped water	0.02	0.05
Traditional pit latrine	0.27**	0.18*
Ventilated pit latrine	0.10	0.12
Flush toilet	0.22**	0.16*
Treatment for fever, cough, diarrhea	-0.21***	-0.04
Ill, no treatment	-0.19	-0.18
Antenatal checkups for at least 1 pregnancy	0.38***	0.13*
At least 1 vaccine (BCG, DPT, measles)	2.69***	-0.05
All vaccines given	2.49***	-0.02
1 vaccine interacted with age	-0.90***	-0.11
All vaccines interacted with age	-0.80***	-0.09
Constant	-2.95***	-0.15
N	9,882	10,294
F-statistic	20.93	4.24
R-square	0.14	0.03

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Notes: These are ordinary least squares (OLS) regressions with height-for-age Z-scores (HAZ) or weight-for-age Z-scores (WHZ) as the dependent variable.
BCG = tuberculosis vaccine; DPT = diphtheria, pertussis, tetanus vaccine.
Significance values are as follows:* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4. DO INCOME EFFECTS VARY BY LOCATION AND LIVELIHOOD?

Descriptive Statistics

Mean HAZ and mean WHZ are higher in urban areas, and differences of more than 0.5 Z-scores are common (Table 4.1). For HAZ these differences are significant at the 10 percent level, although for WHZ the difference is significant only in the north. This is consistent with earlier findings (see, for example, Ruel, Haddad, and Garrett 1999). Table 4.2 shows similar trends for agricultural and nonagricultural households. In all regions except the northeast, HAZ is higher in nonagricultural households. The difference in HAZ for the northeast is not significant. WHZ is again higher in nonagricultural households than agricultural households, but these differences are not statistically significant except for the north.

Table 4.1—Comparison of child nutritional status Z-scores across rural and urban areas, by region

	Height-for-age		Weight-for-height	
Region	Rural	Urban	Rural	Urban
Central	-1.81	**-1.49**	-0.43	-0.25
East	-1.56	**-1.01**	-0.39	-0.38
North	-1.79	**-1.39**	-0.44	**0.02**
Northeast	-1.60	-1.45	-0.61	-0.40
South	-1.43	**-0.99**	-0.42	-0.27
West	-1.46	**-1.13**	-0.60	-0.58

Source: Authors' calculations from India Human and Development Survey 2005 data (Desai et al. 2008).
Note: Bold entries are significant at 10 percent or lower level.

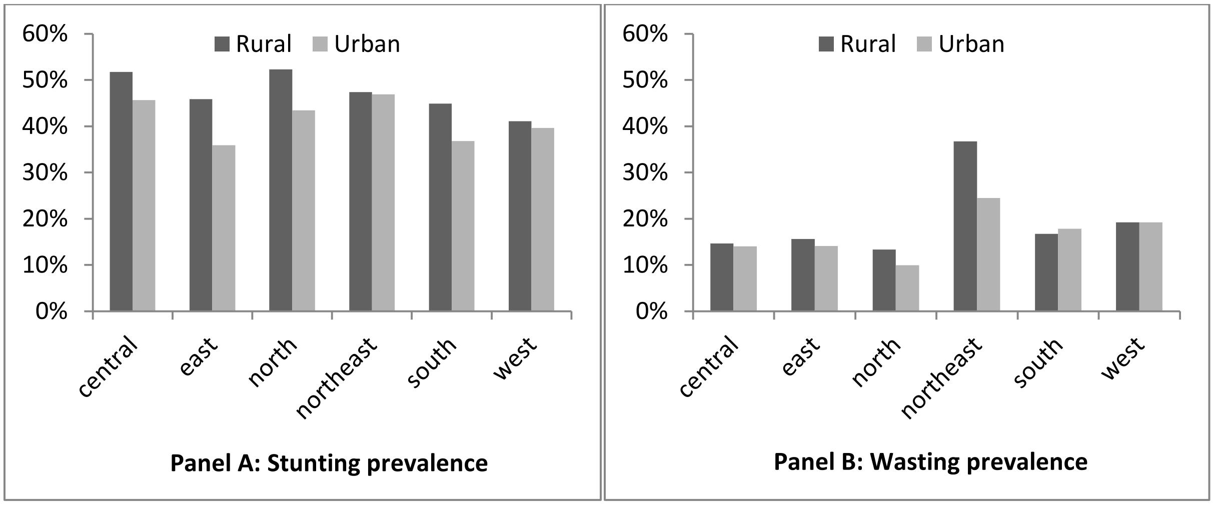
Table 4.2—Comparison of child nutritional status across agricultural and nonagricultural households, by region: Mean Z-scores

	Height-for-age		Weight-for-height	
Region	Nonagricultural	Agricultural	Nonagricultural	Agricultural
Central	-1.67	-1.80	-0.32	-0.44
East	-1.41	**-1.58**	-0.34	-0.45
North	-1.68	**-1.77**	-0.29	**-0.46**
Northeast	-1.65	-1.44	-0.52	-0.71
South	-1.17	**-1.42**	-0.28	-0.49
West	-1.24	**-1.48**	-0.55	-0.65

Source: Authors' calculations from India Human and Development Survey 2005 data (Desai et al. 2008).
Notes: Bold entries are significant at 10 percent or lower level. The comparison being made is against World Health Organization benchmarks.

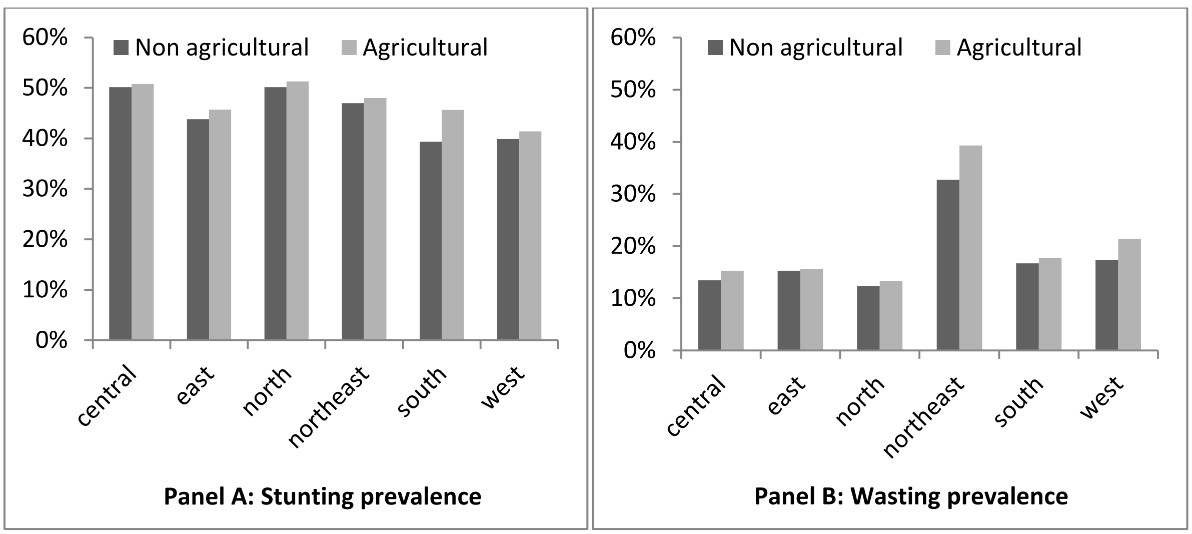
These Z-scores translate into anthropometric failure (Z-scores of less than -2), depicted in Figures 4.1 and 4.2, which show differences in anthropometric failure in terms of stunting or wasting across rural and urban, and agricultural and nonagricultural households. Anthropometric failure is highest for households in rural areas. Agricultural households have a slightly higher rate of stunting and wasting than nonagricultural households, with a greater proportion of children being stunted or wasted. Regional analysis of anthropometric failure shows that the central, north, and northeast regions have higher rates of stunting compared with the south but lower rates of wasting as compared with the south and east.

Figure 4.1—Stunting and wasting across urban and rural areas, by region



Source: Authors calculations from India Human and Development Survey 2005 data (Desai et al. 2008).
Note: Stunting and wasting (the y-axis variables) are defined as Z-scores of less than -2, measured against World Health Organization benchmarks.

Figure 4.2—Stunting and wasting across agricultural and nonagricultural households, by region



Source: Authors' calculations from India Human and Development Survey 2005 data (Desai et al. 2008).
Note: Stunting and wasting (the y-axis variables) are defined as Z-scores of less than -2, measured against World Health Organization benchmarks.

Income Effects in Rural and Urban Areas

We now examine the association of income, water, sanitation, and health factors with HAZ and WHZ in rural and urban areas (Table 4.3). This analysis is useful because although there are differences in levels between rural and urban areas, there may also be differences in marginal impacts. For example, the quality of education, health, or infrastructure could be worse in rural areas.

With regard to income, the effects for lower income quintiles are negatively associated with HAZ and WHZ in both rural and urban areas. However, the HAZ point estimates for income effects are much larger in urban areas (almost twice as large), suggesting high nutrition returns on urban income. It is hard to say why this might be the case. It could be related to urban advantages in terms of access to better foods or better healthcare. Or perhaps rural income is measured with more error, or perhaps wealth is more relevant than income in rural areas. For WHZ we find the opposite result: there is no income gradient for urban areas, but there is a significant gradient for rural areas.

Table 4.3—Effects of income, water, sanitation, and health on nutrition in rural and urban areas

	Height-for-age			Weight-for-height		
	Rural	Urban	Significant rural–urban difference?	Rural	Urban	Significant rural–urban difference?
2nd quintile	-0.12	-0.03		-0.05	0.03	
3rd quintile	-0.09	0.24		0.06	0.03	
4th quintile	0.14	0.05		0.17	0.14	
5th quintile	0.30*	0.68***	Yes	0.34***	-0.01	
Child age (2 years)	-0.62***	-0.54***	Yes	-0.48***	0.07	Yes
Child age (3 years)	0.18	0.32	Yes	-0.14	0.23	Yes
Child age (> 3 years)	1.53***	1.34***	Yes	-0.27	0.52*	Yes
Child sex	0.11	-0.01		-0.01	-0.08	
Household size	-0.02	-0.03		-0.03**	0.02	
Women's education primary	0.17	-0.11		-0.01	0.19	
Women's education secondary	0.27**	0.08		-0.18**	0.14	Yes
Women's decisionmaking	-0.04*	0.02		-0.02	-0.07***	
Mother's age	0.02**	0.01		0.00	-0.02**	
Central	-0.06	-0.65		0.51	0.39	
East	0.09	-0.05		0.56	0.18	
North	-0.09	-0.36		0.44	0.54	
South	-0.13	-0.01		0.26	0.13	
West	0.05	-0.32		0.29	-0.16	
Well water	0.07	-0.41*		-0.10	0.21	Yes
Piped water	0.08	-0.16		0.08	0.00	
Traditional pit latrine	0.22	0.22		0.38***	-0.23**	Yes
Ventilated pit latrine	0.15	-0.15		0.22	-0.15	
Flush toilet	0.29*	0.01		-0.00	0.16	
Treatment for fever or other	-0.17*	-0.35***	Yes	-0.05	-0.09	
Ill, no treatment	-0.13	-0.58*		-0.15	-0.15	
Antenatal checkups	0.39***	0.26*		0.11	0.19	
At least 1 vaccination	2.68***	2.77***		-0.06	-0.19	
All vaccines given	2.48***	2.46***		-0.05	-0.12	
1 vaccine and age	-0.90***	-0.95***		-0.08	-0.23***	
All vaccines and age	-0.80***	-0.79***		-0.05	-0.25***	
Constant	-3.00***	-2.11***		-0.32	0.45	
N	6,895	2,987		7,180	3,114	
F-statistic	13.42	10.40		3.26	4.00	
R-square	0.14	0.14		0.03	0.05	

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Notes: These are ordinary least squares (OLS) regressions with height-for-age Z-scores or weight-for-age Z-scores as the dependent variable. Significance values are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Child age again shows a statistically significant association with both HAZ and WHZ, but the difference in the magnitude is not very large, with the exception of WHZ for children older than three years. Household size has a negative association with HAZ in rural and urban areas but is negatively associated with WHZ in rural areas. Attainment of secondary education for mothers is associated with higher HAZ in rural areas but makes no difference in urban areas. The result for WHZ is the opposite, probably because more-educated mothers may have a higher opportunity cost for staying at home rather than engaging in income generation. As a result, in the short term, nutritional outcomes for children might be affected.

The sanitation results are not very clear. For example, a traditional pit latrine seems to have positive effects on HAZ in urban areas but negative effects on WHZ in urban areas. Flush toilets have positive effects, but only on HAZ in rural areas. The discontinuity in some of the results is of some concern and certainly points to the need to disaggregate results by region.

Finally, the illness impacts tend to be fairly similar, and antenatal checkups have beneficial impacts on HAZ in both rural and urban areas, which is again an encouraging result.

Income Effects in Agricultural and Nonagricultural Households

Table 4.4 reports the results of regressing HAZ and WHZ on the same set of determinants for agricultural and nonagricultural households. Relative to the poorest quintile, children in higher income quintiles also have higher HAZ, but this association is stronger for nonagricultural households (similar to the rural–urban patterns observed above). Child age is again significantly associated with HAZ and WHZ, but the drop in HAZ is sharper for children in agricultural households. This could denote the absence of a diversified diet or poor complementary feeding. An interesting feature is that women's education is associated with higher HAZ and lower WHZ for agricultural households, whereas women's decisionmaking power is associated with lower HAZ and WHZ, although these effects are not statistically significant. We again find inconsistent results for water and sanitation, and we again find favorable effects of antenatal checkups on HAZ.

Differences in Determinants across Rural and Urban Areas and across Agricultural and Nonagricultural Households

The results above suggest that common variables sometimes have significantly different impacts on nutrition in rural/agricultural and urban/nonagricultural households. However, it is also well known that rural and urban areas are categorized by differences in the levels of nutrition determinants, such as differences in incomes and access to services. Table 4.5 therefore compares the levels of the underlying determinants of child nutrition across rural and urban households and across agricultural and nonagricultural households. The table verifies that there are large rural–urban and agricultural–nonagricultural disparities, especially on the variables that have the most influence on undernutrition (stunting). For example, while 28 percent of rural people fall in the bottom income quintile, just under 8 percent of urban households do so. Similarly, just 11 percent of rural households are classified in the top income quintile, while 29 percent of urban households fall into this category. Since only the top quintile shows much better nutrition outcomes, the rural population seems to benefit very little from income-related reductions in undernutrition. For women's secondary education, the differences are even larger (27 percent in rural areas versus 58 percent in urban). There are similarly large or larger differences in access to flush toilets and piped water (although these appear to be poor indicators of safe water or sanitation). Urban children also have much greater access to all vaccinations (63 percent versus 43 percent) and antenatal checkups (almost 90 percent versus 69 percent). These results therefore suggest that the main difference between rural and urban malnutrition determinants relates to differences in levels of the determining variables, not differences in impacts. However, the key exception to this is income, where differences in levels and marginal impacts are evident across the rural–urban divide.

Table 4.4—Effects of income, water, sanitation, and health on nutrition across agricultural and nonagricultural households

	Height-for-age			Weight-for-age		
	Nonagri-cultural	Agri-cultural	Significant agricultural–nonagricultural difference?	Nonagri-cultural	Agri-cultural	Significant agricultural–nonagricultural difference?
2nd quintile	-0.20	0.00		-0.00	-0.07	
3rd quintile	-0.01	0.00		0.04	0.08	
4th quintile	0.15	0.03		0.12	0.16	
5th quintile	0.57***	0.26		0.05	0.41**	
Child age (2 years)	-0.89***	-0.19		-0.29*	-0.43***	Yes
Child age (3 years)	0.03	0.46*	Yes	-0.16	0.08	Yes
Child age (> 3 years)	1.19***	1.94***	Yes	-0.14	-0.04	Yes
Child sex	-0.03	0.22**	Yes	-0.06	0.01	
Household size	-0.05***	-0.00		0.01	-0.04***	
Women's education primary	-0.04	0.29**		0.02	0.05	
Women's education secondary	0.07	0.43***		-0.02	-0.21*	
Women's decisionmaking	-0.03	-0.01		-0.03	-0.03	
Mother's age	0.02**	0.02*		-0.01	0.00	
Central	0.01	-0.70		0.02	1.62***	Yes
East	0.30	-0.51		0.01	1.63***	Yes
North	0.08	-0.71		0.05	1.50***	Yes
South	0.35	-0.76	Yes	-0.18	1.35***	Yes
West	0.26	-0.70		-0.29	1.32***	Yes
Well water	-0.27**	0.24*	Yes	-0.01	-0.07	
Piped water	-0.08	0.19		-0.03	0.16	
Traditional pit latrine	0.26**	0.24		0.08	0.43***	Yes
Ventilated pit latrine	0.04	0.27		0.17	-0.13	
Flush toilet	0.13	0.39*		0.27***	-0.14	Yes
Treatment for fever or other	-0.19**	-0.25**		-0.09	-0.01	
Ill, no treatment	-0.63	0.04		-0.06	-0.22	
Antenatal checkups	0.42***	0.35***		0.21**	0.03	
At least 1 vaccination	2.51***	2.99***		0.04	-0.14	
All vaccines given	2.24***	2.82***		0.09	-0.12	
1 vaccine and age	-0.85***	-1.00***		-0.10	-0.13	
All vaccines and age	-0.75***	-0.88***	Yes	-0.09	-0.11	
Constant	-2.52***	-3.07***		0.15	-1.21**	
N	5,867	4,015		6,107	4,187	
F-statistic	18.87	8.20		3.60	2.89	
R-square	0.15	0.14		0.03	0.04	

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Notes: These are ordinary least squares (OLS) regressions height-for-age Z-scores or weight-for-age Z-scores as the dependent variable.
Significance values are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4.5—Comparison of child nutrition determinants across household types

Variable	Rural	Urban	Agricultural	Nonagricultural
Economic status				
Income (2005 rupees)	43,936	**70,130**	42,980	**57,840**
Lowest quintile (%)	28.1	**7.8**	31.6	**16.8**
2nd quintile (%)	25.0	**14.2**	23.9	**21.3**
3rd quintile (%)	20.2	**22.0**	19.3	**21.6**
4th quintile (%)	15.7	**26.9**	15.2	**20.8**
5th quintile (%)	11.0	**29.1**	10.0	**19.4**
Women's education				
Primary (%)	14.6	**13.2**	15.8	**13.0**
Secondary (%)	27.4	**58.4**	27.3	**40.5**
Women's status				
Relative decisionmaking power (0-7)	4.8	**5.01**	4.8	**4.9**
Mother's age (years)	27.6	27.3	27.3	**27.6**
Safe water				
Well water (%)	31.2	**9.6**	31.7	**21.7**
Piped water (%)	19.6	**69.0**	20.0	**40.1**
Sanitation				
No toilet (%)	80.0	**34.2**	82.9	**58.4**
Traditional pit latrine (%)	8.3	**15.1**	6.9	**12.2**
Ventilated pit latrine (%)	3.2	**9.0**	2.6	**6.1**
Flush toilet (%)	8.5	**41.7**	7.6	**23.2**
Health				
Treatment for cough, diarrhea, fever (%)	30.1	**30.3**	29.2	**31.0**
Ill, no treatment (%)	1.6	1.1	1.7	1.3
Antenatal checkups (%)	68.6	**89.9**	69.3	**77.1**
No vaccinations (%)	4.0	**2.0**	3.3	**3.7**
At least 1 vaccine given (%)	53.4	35.4	50.4	48.2
All vaccines given (%)	42.7	62.6	46.3	48.1

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Notes: Bold figures indicate significant differences at the 10 percent level or higher for rural–urban and agricultural–nonagricultural comparisons. Where no unit is given, the variable is a dummy variable (see Table 2.1).

5. INCOME, AGRICULTURE, AND DIETS

Our measures of dietary diversity are a dietary diversity score (ranging from 0 to 13 food groups) and budget shares of different food groups, both of which are measured only at the household level. One study showed that dietary diversity at the individual level is an important determinant of child nutrition outcomes (Arimond and Ruel 2006), while Jensen and Miller (2011) argued that nonstaple budget or calorie share is at least a good generic welfare indicator (and indeed, a preferable indicator to total calorie consumption). In this section we explore rural–urban and agricultural–nonagricultural differences in these two types of indicators, before trying to explain what determines these dietary indicators and then testing whether these indicators significantly have an impact on undernutrition indicators.

Dietary Diversity and Income

Table 5.1 shows some significant differences in dietary and expenditure patterns across different types of households. However, the difference in the dietary diversity score is very small and not significantly different across rural and urban households. Perhaps the major difference is in the share of household budget allocated to food items. Cereals have a much higher budget share in rural areas (38.7 percent versus 28.7 percent), while meat, eggs, milk, vegetables, and fruits all have a higher budget share in urban areas, with the largest difference existing for milk products.

Because budget shares identify significant differences across household types while the dietary diversity score does not, we need to use several alternative indicators to explore this issue.

Table 5.1—Comparison of budget shares and dietary diversity across rural and urban areas, agricultural and nonagricultural households

Food group	Rural	Urban	Agricultural	Nonagricultural
Cereals	38.7	**28.7**	39.3	**34.5**
Pulses	6.0	**5.2**	6.0	**5.7**
Meat	5.9	**6.9**	5.2	**6.4**
Eggs	0.8	**1.3**	0.7	**1.1**
Milk	12.3	**17.0**	12.9	**14.3**
Vegetables	11.6	**12.3**	11.4	**12.1**
Fruits	2.0	**4.1**	1.9	**2.8**
Dietary diversity score	7.0	6.8	6.9	**7.0**

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Note: Bold entries are significant at 10 percent or lower level.

Turning to explanations of dietary patterns, Table 5.2 shows that the dietary diversity score is positively correlated with economic status, but there is no significant difference among the bottom three income quintiles for nonagricultural households. Children in lower income quintiles have lower dietary diversity scores in both agricultural and nonagricultural households. Household size increases dietary diversity score for both agricultural and nonagricultural households, as does women's education and decisionmaking. There appear to be regional determinants of dietary diversity as well. For nonagricultural households, diets in the northeast (the omitted category) are much less diversified than those in other regions, particularly the central and northern regions. However, for agricultural households, the north region is by far the most diversified. Religion appears to affect dietary diversity as well. Relative to Hindu households, all other agricultural households seem to have lower dietary diversity scores.

Table 5.2—Effects of income, water, sanitation, and health on dietary diversity

	Nonagricultural	Agricultural
Lowest quintile (omitted)		
2nd quintile	-0.03	0.09
3rd quintile	0.02	0.15**
4th quintile	0.05	0.27***
5th quintile	0.18**	0.36***
Child age category (≤ 1 year) (omitted)		
Child age category (2 years)	-6.79***	-6.39***
Child age category (3 years)	-6.72***	-6.27***
Child age category (> 3 years)	-6.65***	-6.10***
Age 2 years and dietary diversity	0.98***	0.94***
Age 3 years and dietary diversity	0.98***	0.94***
Age > 3 years and dietary diversity	0.98***	0.94***
Child sex (male)	0.03	0.01
Household size	0.02*	0.04***
Women's education—none (omitted)		
Women's education primary	0.14*	-0.00
Women's education secondary	0.09	0.11*
Women's decisionmaking power	0.04***	0.06***
Mother's age	-0.00	0.00
Northeast (omitted)		
Central	0.25*	0.05
East	0.18	0.22
North	0.36***	0.50***
South	0.10	0.10
West	0.21	0.05
Other water source (omitted)		
Well water	0.02	-0.00
Piped water	-0.18***	-0.06
No toilet (omitted)		
Traditional pit latrine	0.07	0.07
Ventilated pit latrine	-0.06	-0.28
Flush toilet	0.10*	-0.07
No illness (omitted)		
Ill and treated for fever, cough, diarrhea	0.03	0.15**
Ill and no treatment	0.07	0.17
Antenatal checkups for at least 1 pregnancy	-0.17***	-0.19***
At least 1 vaccination (BCG, DPT, measles)	0.55**	0.80***
All vaccines given	0.06	0.40*
1 vaccine and age	-0.14**	-0.21***
All vaccines and age	0.00	-0.08
Muslim (Hindu omitted)	0.06	0.09
Christian(Hindu omitted)	-0.01	-0.47**
Sikh(Hindu omitted)	-0.15	-0.24*
Other(Hindu omitted)	-0.34**	-0.28**
Constant	6.36***	5.62***
N	7,106	4,829
F-statistic	7,380.04	2,346.99
R-square	0.74	0.75

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Notes: The dependent variable in the above regressions is the dietary diversity score.
BCG = tuberculosis vaccine; DPT = diphtheria, pertussis, tetanus vaccine.
Significance values are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5.3 shows analogous regressions of food group budget shares in agricultural households. Economic status is negatively correlated with the budget shares of cereals, pulses, and vegetables, and positively correlated with milk. There are no significant income effects for meat, eggs, and fruits, surprisingly. Household size has a positive relationship with cereals and a negative relationship with meat, eggs, milk, vegetables, and fruits. Women's secondary education is also associated positively with fruits. Regional effects are also significant. Households in the east and central regions appear to spend much more on cereals than those in all other regions, presumably related to the strong preference for rice consumption in these two regions. The small northeastern states also appear to eat more meat but fewer pulses, and there is some regional variation in fruit and vegetable consumption (lower in the north and central regions for vegetables, and lower in the central and eastern regions for fruits). Not surprisingly, most of the other determinants do not seem to have systematic or large effects on budget shares (such as demographics, sanitation, water, and health; see the notes for Table 5.3). However, women's decisionmaking power seems to increase the food budget allocated to eggs, vegetables, and fruits, but decrease the share allocated to meat.

To examine more closely which aspects of agriculture are related to dietary diversity, we also regress the dietary diversity score and budget shares of different food groups on economic status and on variables that reflect agricultural production systems. The results in Table 5.4 therefore apply only to agricultural households. As expected, economic status has a positive effect on the budget shares of different food groups. Relative to the poorest income quintile, households in the higher income groups have higher dietary diversity scores and higher budget shares of milk. Higher landownership is negatively associated with the budget shares of cereals and vegetables. Irrigated cropland also has a positive association with the dietary diversity score, although it does not appear to have a statistically significant association with other budget shares, except for meat. Crop diversity—denoted by the number of crops grown by the household—is positively associated with the dietary diversity score and the share of pulses, but negatively associated with the share of meat. We also note that irrigation is quite a strong predictor of crop diversity, with a bivariate correlation of around 0.30.

Farm equipment is a dummy variable that takes a value of 1 if the household owns at least one tractor, tubewell, bullock cart, electric or diesel pump, biogas plant, or thresher. Ownership of farm equipment is negatively associated with dietary diversity and with budget share of cereals and fruits. Ownership of animals and livestock is positively correlated with the dietary diversity score, but not with meat or egg consumption. However, ownership of cows and buffalo is very strongly related to milk consumption, suggesting that own-consumption of dairy products is indeed important, as one would expect. Similarly, ownership of poultry is associated with the budget share of meat but not eggs. Membership in an agricultural or milk cooperative is also negatively associated with the budget share of cereals and positively associated with meat consumption (but not dairy consumption).

All in all, these results suggest that agricultural income and production conditions significantly and substantially explain dietary patterns across agricultural households. These effects probably take place through two channels. First, since income is in some sense only a proxy for wealth (including agricultural wealth), more agricultural assets may simply indicate greater purchasing power and hence greater capacity to purchase different foods. Second, more agricultural assets allow more diversity of production and therefore more diversity in own-consumption. For example, animal ownership seems to allow greater consumption of milk, and crop diversity is associated with increased cereal and pulse consumption.

Table 5.3—Effects of income, water, sanitation, and health on budget shares of different food groups, agricultural households

	Cereals	Pulses	Meat	Eggs	Milk	Vegetables	Fruits
2nd quintile	0.02	-0.05	-0.06	-0.10	0.13**	0.01	-0.04
3rd quintile	-0.08***	-0.04	0.00	-0.02	0.20***	-0.08**	-0.00
4th quintile	-0.15***	-0.18***	-0.06	-0.06	0.38***	-0.11***	0.06
5th quintile	-0.32***	-0.29***	0.03	-0.10	0.59***	-0.24***	0.07
Child age category (2 years)	-0.04*	0.01	0.03	0.02	0.02	0.08**	-0.07
Child age category (3 years)	-0.06*	0.01	0.02	0.10	0.00	0.13**	-0.11
Child age category (> 3 years)	-0.03	0.01	-0.01	-0.04	-0.00	0.21***	-0.25*
Child sex (male)	-0.01	0.03*	0.02	-0.03	0.02	-0.03	-0.06*
Household size	0.02***	-0.00	-0.03***	-0.04***	-0.01	-0.01*	-0.02**
Women's education primary	-0.04	0.02	-0.01	-0.02	0.06	-0.03	0.07
Women's education secondary	-0.04**	0.06*	-0.02	-0.05	-0.01	-0.01	0.15**
Women's decisionmaking power	-0.00	0.01	-0.02**	0.01	0.02	0.03***	0.02
Mother's age	0.01***	-0.00*	-0.00	0.00	-0.01**	-0.00*	-0.01
Central	0.25***	0.35***	-0.63***	-0.29	-0.04	-0.40***	-0.33*
East	0.27***	0.17	-0.64***	-0.35***	-0.17	0.05	-0.58***
North	-0.10	0.42***	-0.54***	-0.26*	0.20	-0.20	0.05
South	-0.04	0.43***	-0.37**	-0.26*	-0.21	-0.13	0.36*
West	-0.24***	0.22*	-0.49***	-0.18	0.12	-0.17	-0.10
Well water	-0.04*	-0.03	0.01	-0.10	0.03	-0.00	-0.03
Piped water	-0.07**	-0.08	0.01	-0.26***	-0.00	0.06	0.08
Ill and treated for fever or other	0.00	0.06**	-0.12***	-0.09	-0.11***	-0.02	-0.01
Ill and no treatment	0.21***	-0.02	0.05	-0.21*	-0.06	-0.12	-0.00
Antenatal checkups	-0.03	0.00	0.09*	0.08	-0.05	0.01	0.04
At least 1 vaccination	-0.02	0.13	-0.14	-0.33***	-0.06	0.13**	-0.27*
All vaccines given	-0.02	0.12	-0.11	-0.41***	0.00	0.14*	-0.28
1 vaccine and age	0.01	0.00	-0.00	-0.00	0.02	-0.05***	0.06
All vaccines and age	0.00	-0.01	-0.01	-0.00	-0.00	-0.05**	0.08**
Muslim	-0.07**	-0.22***	0.20***	-0.00	-0.15	-0.07	0.24***
Christian	0.08	-0.14	0.25	-0.03	0.15	0.14	-0.49***
Sikh	-0.20***	-0.42**	0.35*	-1.73*	0.29***	-0.03	0.36**
Other	0.03	-0.30**	0.33***	0.06	-0.39**	0.08	0.00
Constant	-1.16***	-3.16***	-1.66***	-3.16***	-2.15***	-2.14***	-3.31***
N	4,844	4,582	2,552	1,268	3,479	4,693	2,822
F-statistic	39.54	4.87	4.65	2.38	6.65	6.97	9.72
R-square	0.39	0.11	0.13	0.09	0.12	0.13	0.24

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Notes: These are ordinary least squares (OLS) regressions.
Significance values are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. For brevity, we omit results for sanitation.

Table 5.4—Effects of agricultural variables on dietary diversity and food budget shares

Dependent variable	DDI	Cereals	Pulses	Meat	Eggs	Milk	Vegetables	Fruits
2nd quintile	0.21	-0.00	-0.04	-0.02	-0.07	0.12	-0.07**	-0.00
3rd quintile	0.49***	-0.07**	-0.02	-0.04	-0.08	0.18***	-0.10***	0.05
4th quintile	0.49***	-0.15***	-0.13***	-0.07	-0.06	0.29***	-0.13***	0.12
5th quintile	0.84***	-0.24***	-0.26***	0.07	-0.23**	0.33***	-0.21***	0.20**
Land area owned (hectares)	-0.01	-0.02***	-0.01	0.02**	0.00	0.01	-0.01*	0.01
Irrigation for at least 1 crop	0.79***	0.05*	0.01	-0.06	0.08	-0.05	0.06	-0.15**
Number of crops	0.32***	0.01**	0.04***	-0.03**	-0.01	-0.03**	-0.00	-0.01
Farm equipment owned	-0.48***	-0.07***	-0.00	0.04	-0.06	0.14***	-0.10***	0.11
Membership in cooperative	0.12	-0.15***	-0.03	0.19**	-0.09	0.05	0.09	0.01
Ownership of cows	-0.02	-0.00	-0.03	-0.02	-0.11*	0.28***	-0.06**	-0.18***
Ownership of milch buffalo	0.98***	-0.21***	-0.10**	-0.23***	-0.09	0.55***	-0.14***	-0.06
Ownership of goats	0.25	0.05**	-0.13***	-0.02	0.04	0.16**	-0.01	-0.21**
Ownership of sheep	-0.36	0.03	0.02	0.14	-0.20	-0.04	-0.13*	-0.44***
Ownership of poultry	-0.37*	0.08***	-0.35***	0.21***	0.06	-0.19*	0.02	0.15*
Constant	5.20***	-0.88***	-2.85***	-2.51***	-3.99***	-2.72***	-2.10***	-3.65***
N	4,927	4,921	4,673	2,581	1,305	3,633	4,802	2,974
F-statistic	19.47	28.95	10.14	6.84	1.70	16.52	9.64	3.15
R-square	0.18	0.21	0.11	0.09	0.04	0.18	0.09	0.05

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Notes: DDI = Dietary diversity score.
Significance values are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5.5 reports the results of regressing the dietary diversity score on the same explanatory variables as before but for different land sizes. The two most interesting results relate to irrigation and farm equipment. Irrigation increases dietary diversity on small and marginal farms but has no impact on dietary diversity on medium and large farms. The marginal effects are also quite large (1.46 extra food items for irrigated marginal farms, and 0.8 extra items for irrigated small farms). This makes sense, given that smaller farms need to get as much value as they can out of their constrained land area, which irrigation certainly allows. Irrigation may also allow greater diversity in own-consumption (for example, by allowing small farms to grow vegetables). Interestingly, we observe an opposite relationship for farm equipment. This may be because the ownership of a tractor, for example, inhibits more diverse production because the tractor may be useful only for the production of cereals. This is only speculation, however.

Table 5.5—Effects of agricultural production conditions on dietary diversity, by land size

Hectares (ha) →	Marginal farms < 0.5 hectare	Small farms 0.5–2 hectares	Medium farms 2–5 hectares	Large farms > 5 hectares
2nd quintile	0.61***	-0.20	0.22	-1.30***
3rd quintile	0.81***	0.02	0.68	-1.21***
4th quintile	0.83***	0.51**	0.84**	0.02
5th quintile	2.00***	0.62**	1.35***	0.18
Irrigation for at least 1 crop	1.46***	0.88***	0.36	0.18
Number of crops	0.34***	0.33***	0.35***	0.22*
Farm equipment owned	-0.85***	-0.38**	-0.66*	-1.00*
Animal ownership	0.45	0.66**	-0.51	-2.72**
Membership in cooperative	0.51	0.33	-0.20	0.12
Constant	4.60***	5.16***	6.22***	10.48***
N	2,708	2,841	1,292	472
F-statistic	18.82	18.54	8.42	3.35
R-square	0.16	0.14	0.13	0.09

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Notes: The dependent variable is the D\dietary diversity score described in the text.
Significance values are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5.6 presents results of regressing the budget share of cereals on agricultural factors by land size. Economic status is negatively associated with the share of cereals for all land sizes. However, the magnitude of this effect is higher for poorer households and those with marginal and small farms. Presumably, better economic status implies more expenditure on non-cereal food groups, as seen in previous regressions. Ownership of farm equipment and membership in agricultural cooperatives are negatively associated with cereal share, especially for medium-sized farms. Ownership of farm animals is positively associated with cereal share in food expenditure.

Table 5.6—Effects of agriculture on budget share of cereals, by land size

Regression no.	1	2	3	4
	Marginal farms < 0.5 hectare	**Small farms 0.5–2 hectares**	**Medium farms 2–5 hectares**	**Large farms > 5 hectares**
2nd quintile	-0.01	0.01	-0.07	0.05
3rd quintile	-0.12***	-0.09**	-0.04	-0.03
4th quintile	-0.17***	-0.18***	-0.26***	-0.05
5th quintile	-0.33***	-0.29***	-0.31***	-0.15
Irrigation for at least 1 crop	0.00	-0.01	0.01	0.07
Number of crops	0.00	0.01	0.01	-0.01
Farm equipment owned	-0.00	-0.05	-0.12**	-0.02
Animal ownership	0.00	0.06	0.23***	0.13
Membership in cooperative	0.08*	-0.21***	-0.16***	-0.16**
Constant	-0.85***	-0.97***	-1.14***	-1.34***
N	2,702	2,839	1,291	472
F-statistic	5.96	13.46	9.14	1.79
R-square	0.06	0.09	0.13	0.07

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Notes: The dependent variable is the share of the household food budget allocated to cereals.
Significance values are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Although there are important agricultural determinants of household dietary diversity, it actually proves quite difficult to relate household dietary diversity to individual nutrition outcomes. The results in Table 5.7 show that neither the dietary diversity score nor the food group budget shares significantly explain HAZ or WHZ. In retrospect, this is perhaps not so surprising, since diets in this case are measured at the household rather than individual level. Results using indicators at the individual level from the National Family Health Surveys consistently show that dietary diversity explains stunting. Measurement error could be an issue for both the dietary diversity score and the budget shares, while misspecification could also be problematic. For example, there may be important interactions between children's age, illness, maternal decisionmaking power, breast-feeding patterns, and so on.

Table 5.7—Effects of household dietary diversity indicators on nutrition outcomes

Regression no.	1	2	3	4
Indicator of diets used	Household dietary diversity score		Budget shares	
Dependent variable	HAZ	WHZ	HAZ	WHZ
2nd quintile	0.02	-0.03	0.34	0.05
3rd quintile	-0.02	0.12	0.27	-0.25
4th quintile	0.06	0.30**	-0.11	-0.32
5th quintile	0.24	0.46***	0.62**	-0.52*
Child age category (2 years)	-1.14***	-0.07	-1.22***	-0.21
Child age category (3 years)	-1.95***	-0.06	-1.14***	-0.31
Child age category (>3 years)	-1.83***	-0.38	-1.07***	-0.34
Age 2 years and dietary diversity	-0.05	-0.07*	–	–
Age 3 years ad dietary diversity	0.02	-0.02	–	–
Age >3 years and dietary diversity	0.04	-0.01	–	–
Child sex	0.11	0.05	-0.19	0.09
Household size	-0.00	-0.03*	-0.08**	-0.02
Women’s education primary	0.30**	-0.04	0.16	-0.10
Women’s education secondary	0.40***	-0.12	0.60**	0.04
Well water	0.23**	-0.07	0.15	0.01
Piped water	0.22*	-0.05	0.41*	-0.18
Traditional pit latrine	0.33*	0.22	0.29	0.83***
Ventilated pit latrine	0.44**	0.01	-0.04	0.77
Flush toilet	0.25	-0.11	-0.18	0.20
Antenatal checkups	0.39***	-0.02	0.27	-0.16
Dietary indicators				
Dietary diversity score	-0.02	-0.02		
Cereals	–	–	0.25	-0.05
Pulses	–	–	0.14	-0.07
Meat	–	–	0.09	0.03
Eggs	–	–	-0.13	0.02
Milk	–	–	0.15	0.09
Vegetables	–	–	0.32	-0.15
Fruits	–	–	-0.18	0.14
Constant	-0.88**	0.05	0.03	0.34
N	5,300	5,579	760	799
F-statistic	14.29	3.62	2.91	1.74
R-square	0.11	0.03	0.12	0.06

Source: Authors’ calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Notes: HAZ = height-for-age Z-score, WHZ = weight-for-age Z-score.
Significance values are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6. CONCLUSIONS

This paper explored the determinants of stunting and wasting in India, with a special focus on the roles of income, agricultural production, and diets.

Our first finding is that the income gradient for undernutrition is very weak, with only the richest quintile showing much higher height-for-age Z-scores than the rest. This is in some contrast to results from the National Family Health Surveys, where a relatively strong wealth gradient has been found in several studies (Headey, Chiu, and Kadiyala 2012; Headey 2011). This discrepancy may be related to the fact that current income is less effective than assets as a predictor of permanent income, although we also find that income is a better predictor of nutrition in urban areas than in rural areas. But if the finding is not simply a measurement error issue, then it suggests that income growth is not doing much to reduce undernutrition in India, as the most recent evidence on the question suggests.

A second finding pertains to non-income determinants of nutrition outcomes. Of most policy relevance is the significant effect of female secondary education and children's vaccinations (controlling for age), while sanitation and water supply variables have mixed and often insignificant effects. The last finding could be related to the fact that sanitation and water supply indicators are only poor proxies for the actual quality of water and sanitation (indeed, it is not unusual for these variables to be insignificant predictors of nutrition outcomes). In contrast, the significant result for secondary education of women is a common feature in the nutrition literature, suggesting very high returns on investments in female education, especially in rural areas of India, where female education rates are often abysmally low.

The remaining findings focus on the nexus of agricultural production, diets, and undernutrition. Agricultural production conditions are often thought to be crucial determinants of nutrition outcomes, although there is remarkably little robust evidence to bear on this front. In contrast to some existing evidence suggesting that dietary diversity is simply a function of income, whatever the source, our results suggest that agricultural production conditions substantially influence household dietary diversity. Specifically, irrigation has a substantial impact on dietary diversity for marginal and small farms (which the vast majority of Indian farms are), as does crop diversity, which is itself related to irrigation. Second, ownership of milk-producing livestock (cattle, buffalo, and goats) also predicts much higher household milk consumption, even after controlling for income. Third, poultry ownership increases meat consumption. Other agricultural indicators tend to have insignificant or modest effects on diets. Hence, these results suggest that agricultural programs aimed at irrigation, livestock ownership, and crop diversification all have some scope to increase dietary diversity in India.

APPENDIX: SUPPLEMENTARY TABLES

Table A.1—Effects of income, water, sanitation, and health on height-for-age and weight-for-height Z-scores

	HAZ	WHZ
Log of income	0.06	0.08**
Child age category (2 years)	-0.58***	-0.35***
Child age category (3 years)	0.22	-0.07
Child age category (>3 years)	1.51***	-0.12
Child sex	0.09	-0.03
Household size	-0.01	-0.02*
Women's education primary	0.15	0.02
Women's education secondary	0.30***	-0.10
Women's decisionmaking power	-0.02	-0.03*
Mother's age	0.02**	-0.00
Central	-0.17	0.43
East	0.09	0.44
North	-0.10	0.42
South	0.01	0.21
West	-0.01	0.11
Well water	0.01	-0.06
Piped water	0.05	0.05
Traditional pit latrine	0.28***	0.18**
Ventilated pit latrine	0.16	0.14
Flush toilet	0.28***	0.16*
Treatment for fever, cough, diarrhea	-0.23***	-0.04
Ill, no treatment	-0.24	-0.20
Antenatal checkups for at least 1 pregnancy	0.40***	0.13*
At least 1 vaccination (BCG, DPT, measles)	2.73***	-0.03
All vaccines given	2.52***	0.00
1 vaccine and age	-0.91***	-0.11
All vaccines and age	-0.80***	-0.09
Constant	-3.67***	-0.95*
N	9,845	10,255
F-statistic	21.15	4.56
R-square	0.14	0.03

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Notes: HAZ = height-for-age z-score; WHZ = weight-for-age z-score; BCG = tuberculosis vaccine; DPT = diphtheria, pertussis, tetanus vaccine.
Significance values are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.2—Effects of income, water, sanitation, and health on height-for-age and weight-for-height across rural and urban areas

	Height-for-age		Weight-for-height	
	Rural	Urban	Rural	Urban
Log of income	-0.00	0.28***	0.09**	0.02
Child age category (2 years)[a]	-0.61***	-0.52***	-0.47***	0.05
Child age category (3 years)[a]	0.19	0.35	-0.13	0.20
Child age category (>3 years)[a]	1.55***	1.37***	-0.25	0.47
Child sex	0.11	-0.00	-0.01	-0.08
Household size	-0.00	-0.03	-0.02*	0.02
Women's education primary	0.19*	-0.10	0.00	0.18
Women's education secondary	0.31***	0.10	-0.17*	0.12
Women's decisionmaking power	-0.04	0.01	-0.02	-0.06***
Mother's age	0.02**	0.01	0.00	-0.02**
Central	-0.08	-0.63	0.50	0.47
East	0.07	-0.02	0.55	0.25
North	-0.10	-0.34	0.44	0.61*
South	-0.13	0.00	0.24	0.21
West	0.02	-0.32	0.27	-0.08
Well water	0.07	-0.42*	-0.11	0.21
Piped water	0.10	-0.18	0.08	0.00
Traditional pit latrine	0.25*	0.18	0.39***	-0.22**
Ventilated pit latrine	0.24	-0.16	0.26	-0.15
Flush toilet	0.36**	0.00	-0.01	0.16
Treatment for fever, cough, diarrhea	-0.18**	-0.37***	-0.05	-0.08
Ill, no treatment	-0.19	-0.57*	-0.18	-0.15
Antenatal checkups for at least 1 pregnancy	0.42***	0.26*	0.12	0.18
At least 1 vaccination (BCG, DPT, measles)[b]	2.72***	2.84***	-0.03	-0.18
All vaccines given	2.52***	2.55***	-0.01	-0.13
1 vaccine and age	-0.90***	-0.97***	-0.09	-0.22***
All vaccines and age	-0.80***	-0.79***	-0.06	-0.23***
Constant	-3.12***	-4.95***	-1.22*	0.22
N	6,869	2,976	7,153	3,102
F-statistic	13.41	11.42	3.46	4.32
R-square	0.13	0.14	0.03	0.05

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).

Notes: [a] Children's ages are only given in years, hence these values should be considered approximate only.

[b] BCG = tuberculosis vaccine; DPT = diphtheria, pertussis, tetanus vaccine.

Significance values are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.3—Effects of income, water, sanitation, and health on dietary diversity

	Nonagricultural	Agricultural
Log of income	0.09*	0.09***
Child age category (2 years)	-6.79***	-6.42***
Child age category (3 years)	-6.74***	-6.30***
Child age category (>3 years)	-6.67***	-6.14***
Age 2 years and dietary diversity	0.98***	0.94***
Age 3 years and dietary diversity	0.98***	0.94***
Age >3 years and dietary diversity	0.98***	0.95***
Child sex (male)	0.04	0.01
Household size	0.02*	0.04***
Women's education primary	0.14*	0.01
Women's education secondary	0.09	0.13**
Women's decisionmaking power	0.04***	0.06***
Mother's age	-0.00	0.00
Central	0.25*	-0.00
East	0.18	0.16
North	0.36***	0.45***
South	0.10	0.04
West	0.20	-0.01
Well water	0.03	0.00
Piped water	-0.18***	-0.05
Traditional pit latrine	0.06	0.07
Ventilated pit latrine	-0.07	-0.21
Flush toilet	0.10*	-0.04
Ill & treated for fever, cough, diarrhea	0.03	0.15**
Ill & no treatment	0.08	0.15
Antenatal checkups for at least 1 pregnancy	-0.16**	-0.19***
At least 1 vaccination (BCG, DPT, measles)	0.53**	0.76***
All vaccines given	0.05	0.35
1 vaccine and age	-0.13**	-0.21***
All vaccines and age	0.01	-0.07
Muslim	0.05	0.08
Christian	-0.02	-0.50**
Sikh	-0.16	-0.24*
Other	-0.35**	-0.28**
Constant	5.52***	4.92***
N	7,072	4,819
F-statistic	7,613.33	2,589.58
R-square	0.74	0.75

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Notes: BCG = tuberculosis vaccine; DPT = diphtheria, pertussis, tetanus vaccine.
Significance values are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.4—Effects of income, water, sanitation, and health on budget shares of different food groups, agricultural households

	Cereals	Pulses	Meat	Eggs	Milk	Vegetables	Fruits
Log of income	-0.08***	-0.08***	-0.01	-0.01	0.17***	-0.07***	0.03
Child age (2 years)	-0.05**	-0.00	0.03	0.02	0.04	0.07*	-0.07
Child age (3 years)	-0.07**	-0.00	0.02	0.09	0.02	0.12**	-0.11
Child age (>3 years)	-0.05	-0.01	-0.01	-0.04	0.03	0.19***	-0.25*
Child sex (male)	-0.02	0.03*	0.02	-0.02	0.03	-0.03	-0.06
Household size	0.01***	-0.01	-0.03***	-0.04***	-0.01	-0.01**	-0.02**
Women education-primary	-0.06*	0.01	-0.01	-0.01	0.09	-0.05	0.07
Women education-secondary	-0.06**	0.05	-0.02	-0.05	0.01	-0.01	0.15**
Women-decisionmaking	-0.01	0.01	-0.02**	0.01	0.02	0.03***	0.02
Mother's age	0.01***	-0.00*	-0.00	0.00	-0.01**	-0.00*	-0.01
Central	0.27***	0.37***	-0.65***	-0.30	-0.00	-0.38***	-0.31
East	0.28***	0.19*	-0.65***	-0.34***	-0.15	0.06	-0.56***
North	-0.10	0.43***	-0.54***	-0.26*	0.25	-0.19	0.06
South	-0.02	0.45***	-0.38**	-0.25*	-0.18	-0.12	0.38*
West	-0.22***	0.24**	-0.49***	-0.18	0.14	-0.15	-0.09
Well water	-0.03	-0.02	0.01	-0.10	0.03	0.01	-0.03
Piped water	-0.07**	-0.07	0.02	-0.25***	-0.00	0.07	0.08
Ill & treated	0.01	0.06**	-0.12***	-0.09	-0.11***	-0.02	-0.01
Ill & no treatment	0.24***	0.00	0.05	-0.21*	-0.09	-0.10	-0.01
Antenatal checkups	-0.04*	-0.00	0.10*	0.08	-0.04	-0.00	0.05
At least 1 vaccine	-0.03	0.12	-0.13	-0.32**	-0.05	0.12*	-0.27*
All vaccines given	-0.04	0.11	-0.10	-0.41***	0.02	0.13*	-0.28
1 vaccine*age	0.02	0.01	-0.00	0.00	0.01	-0.05***	0.06
All vaccines*age	0.01	-0.00	-0.01	-0.00	-0.01	-0.05**	0.08*
Muslim	-0.07**	-0.21***	0.20***	-0.01	-0.16	-0.06	0.24***
Christian	0.07	-0.13	0.24	-0.02	0.10	0.14	-0.47***
Sikh	-0.20***	-0.43**	0.39**	-1.74*	0.29***	-0.03	0.35**
Other	0.03	-0.30**	0.33***	0.07	-0.45**	0.07	0.01
Constant	-0.42***	-2.39***	-1.62***	-3.11***	-3.76***	-1.46***	-3.68***
N	4,836	4,574	2,545	1,265	3,471	4,686	2,815
F-statistic	42.53	5.64	5.00	2.57	6.92	7.42	10.74
R-square	0.37	0.10	0.13	0.08	0.11	0.13	0.23

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Notes: BCG = tuberculosis vaccine; DPT = diphtheria, pertussis, tetanus vaccine.
Significance values are as follows: * $p< 0.10$, ** $p< 0.05$, *** $p< 0.01$.

Table A.5—Effects of agriculture on dietary diversity, agricultural households

	DDI	Cereals	Pulses	Meat	Eggs	Milk	Vegetables	Fruits
Log of income	0.22***	-0.07***	-0.07***	-0.01	-0.04	0.12***	-0.06***	0.07***
Land area owned (ha)	-0.00	-0.02***	-0.01	0.03***	-0.00	0.01	-0.01*	0.01
Irrigation at least 1 crop	0.79***	0.05**	0.00	-0.05	0.07	-0.05	0.06	-0.15**
Number of crops	0.33***	0.01**	0.03***	-0.03**	-0.01	-0.03**	-0.00	-0.01
Farm equipment owned	-0.45***	-0.08***	-0.01	0.04	-0.06	0.15***	-0.11***	0.12*
Cooperative Member	0.14	-0.15***	-0.04	0.20***	-0.10	0.05	0.08	0.01
Ownership of cows	0.00	-0.00	-0.03	-0.02	-0.11*	0.28***	-0.06**	-0.18***
Ownership of buffalo	1.01***	-0.21***	-0.10**	-0.23***	-0.09	0.56***	-0.14***	-0.06
Ownership of goats	0.25	0.05**	-0.13***	-0.03	0.04	0.16**	-0.01	-0.21**
Ownership of sheep	-0.36	0.03	0.03	0.13	-0.19	-0.03	-0.12*	-0.43**
Ownership of poultry	-0.38*	0.08***	-0.35***	0.21***	0.06	-0.20**	0.03	0.14*
Constant	3.22***	-0.19**	-2.18***	-2.41***	-3.66***	-3.74***	-1.54***	-4.31***
N	4,927	4,921	4,673	2,581	1,305	3,633	4,802	2,974
F-statistic	24.91	36.03	10.01	8.59	1.60	20.63	12.06	3.81
R-square	0.18	0.21	0.11	0.08	0.03	0.18	0.09	0.05

Source: Authors' calculations from India Human and Development Survey 2005 (Desai et al. 2008).
Notes: DDI = Dietary diversity score.
Significance values are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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Fax: +1-202-467-4439
Email: ifpri@cgiar.org

IFPRI ADDIS ABABA

P. O. Box 5689
Addis Ababa, Ethiopia
Tel.: + 251 (0) 11-617-2500
Fax: + 251 (0) 11-646-2927
Email: ifpri-addisababa@cgiar.org

IFPRI NEW DELHI

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New Delhi 110-012 India
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