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**Understanding the Rapid Reduction of  
Undernutrition in Nepal, 2001–2011**

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## ABSTRACT

South Asia has long been synonymous with unusually high rates of undernutrition. In the past decade, however, Nepal has arguably achieved the fastest recorded decline in child stunting in the world and has done so in the midst of civil war and postconflict political instability. Given recent interest in reducing undernutrition—particularly the role of nutrition-sensitive policies—this paper aims to quantitatively understand this surprising success story by analyzing the 2001, 2006, and 2011 rounds of Nepal’s Demographic Health Surveys. To do so, the authors first construct and test basic models of the intermediate determinants of child and maternal nutritional change and then decompose predicted changes in nutrition outcomes over time. They identify four broad drivers of change: asset accumulation, health and nutrition interventions, maternal educational gains, and improvements in sanitation. Many of these changes were clearly influenced by policy decisions, including increased public investments in health and education and community-led health and sanitation campaigns. Other factors, such as rapid growth in migration-based remittances, are more a reflection of household responses to changing political and economic circumstances.

**Keywords:** maternal and child nutrition; Nepal; economic growth; education; sanitation; health services

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# 1. INTRODUCTION

*“The countries of the South Asian region must now face up to the fact that they have the worst nutritional levels in the world, and that the roots of malnutrition run deep into social soils.”*

Ramalingaswami, Jonson, and Rohde (1997)

Scientists of many disciplines have long been puzzled as to why South Asian countries have such unusually high rates of malnutrition, especially relative to Africa south of the Sahara (Deaton and Dreze 2008; Headey, Chiu, and Kadiyala 2012; Jayachandran and Pande 2013; Nubé 2007; Pande 2003; Ramalingaswami, Jonson, and Rohde 1997; Spears 2013). Since the term was first popularized in the mid-1990s, however, the nature of the Asian enigma has changed significantly. In the 1990s Nepal had the highest rate of child stunting in the world, with around 60 percent of children younger than 5 years being stunted, many of them severely so. In the past 10 years, however, Nepal has arguably recorded the fastest reduction in child stunting in the world (Table 1.1), reducing child stunting from 57.1 to 40.5 percent, a reduction of 1.66 points per year.<sup>1</sup> Bangladesh—the subject of a companion paper (Headey et al. 2014)—made similarly impressive progress from 1996 to 2007. The success of these two South Asian countries stands in stark contrast to India (which made modest improvements in stunting from 1993 to 2006) and Pakistan and Sri Lanka (both of which recorded no improvement in the 2000s). Moreover, both Nepal and Bangladesh achieved this success without the stellar economic growth rates of China or Vietnam, and Nepal did so in the midst of a violent Maoist insurgency (2001–2006) and subsequent political instability and uncertainty (2006–2011).

In this paper we try to understand Nepal’s dramatic success through a quantitative analysis of four rounds of Demographic Health Survey (DHS) data (1996, 2001, 2006, and 2011). Therefore, the paper is related to, but nevertheless distinct from, several strands of the nutrition literature. First, the aforementioned literature on the South Asian enigma has also attempted to identify the determinants of undernutrition in South Asia, but largely through static approaches such as Asia-Africa comparisons. In contrast, this paper is a rare attempt to understand nutritional change over time.

Second, there is indeed a small but somewhat diverse literature on nutrition success stories, which has largely been qualitative and focused on questions of policy and political process, including the important question of multisectoral nutrition efforts (Acosta and Fanzo 2012; Heaver 2002; Heaver and Kachondam 2002; World Bank 2006). While such studies are important for understanding the deeper social and political drivers of nutritional change (which this study does not do), qualitative and anecdotal case studies of success stories do not generate objective evidence on the contributions of different sectors.

Third, there is a large body of literature focus on rigorously evaluating the nutritional impact of specific interventions, typically nutrition-specific interventions (Bhutta et al. 2008; Black et al. 2013). Though internally rigorous, control trials typically say little about the larger programmatic impacts over space or time (Elbers and Gunning 2013). The literature, moreover, is focused heavily on nutrition-specific interventions, with much less emphasis on nutrition-sensitive interventions. Yet it has long been known that nutrition-specific interventions cannot eradicate malnutrition by themselves and that a wide array of “nutrition-sensitive” interventions must play a central role in achieving this task. Indeed, one of the studies in the recent *Lancet* series on nutrition found that extending coverage of 10 essential nutrition-specific interventions to 90 percent coverage in the 34 highest-burden countries would reduce stunting by only about one-fifth (Bhutta et al. 2013). By implication, most future nutritional change must therefore

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<sup>1</sup> This claim is based on an analysis of World Health Organization (2013) data. There are different ways to calculate the speed of nutritional change. We focused on periods of change of at least a decade, measured change as the absolute change in the prevalence of stunting (rather than percentage change), and excluded several countries in which data trends were suspicious (for example, based on different sources that were not obviously comparable). Hence it is by this specific but very relevant metric that Nepal has recorded the fastest change in stunting in recent years.

come from nutrition-sensitive developments in various sectors (such as health, education, family planning, and infrastructure) as well as general economic growth. Unfortunately, control trials are rarely a viable means of assessing larger-scale programs, policies, and other broader economic processes (Elbers and Gunning 2013).

**Table 1.1 The fastest reductions in preschooler stunting in the 2000s at the global level**

Rank	Country	Start and end dates	Start and end stunting (%)	Speed of change (in points per year)
<u>Top 10 countries in speed of reducing child stunting</u>				
1	Nepal	2001	57.1	
		2011	40.5	-1.66
2	Bangladesh	1997	56.7	
		2007	43.2	-1.42
3	Lesotho	2000	53.0	
		2010	39.0	-1.40
4	Vietnam	2000	42.7	
		2010	29.3	-1.34
5	Ethiopia	2000	57.4	
		2011	44.2	-1.20
6	Uganda	2001	44.8	
		2011	33.7	-1.11
7	Honduras	2001	34.5	
		2012	22.7	-1.07
8	Morocco	1997	29.0	
		2011	14.9	-1.01
9	Burkina Faso	1999	45.5	
		2010	35.1	-0.95
10	China	2000	17.8	
		2010	9.4	-0.84
<u>Other South Asian countries</u>				
19	India	1993	57.1	
		2006	47.9	-0.71
69	Pakistan	2001	41.5	
		2011	43.0	0.15
72	Sri Lanka	2000	18.4	
		2009	19.2	0.09

Source: Authors' estimates from 84 recent nutrition episodes recorded in the World Health Organization Global Health Observatory Repository (2014).

Notes: Nutrition episodes are defined as periods of observations at least 8 years apart, with the last observation recorded in 2000s. Several episodes with apparently unreliable data were excluded. Statistics refer to children under the age of five.

In light of these motivations, this paper seeks to understand two basic questions. The first is essentially static: what are the major determinants of nutrition outcomes in Nepal? The second is dynamic: which of these determinants have been driving change in nutrition outcomes over time? In terms of data and methods, we are able to examine a relatively wide array of nutrition indicators (child height-for-age  $z$  scores [HAZs], stunting rates, and severe stunting; a subjective indicator of small size at



birth; and maternal body mass index [BMI] and low BMI prevalence) and explanatory variables (wealth, education, health service utilization, water supply, sanitation, demographic outcomes, and intergenerational transmission). In terms of methods we use nonparametric graphical techniques (which are particularly useful for exploring nonlinear relationships), pooled multivariate regression models, and simple decompositions of nutritional change at population means.

We find that nutritional change in Nepal has indeed been a multifaceted process. Improvements in child growth scores and stunting rates appear to have been most heavily influenced by health and nutrition interventions, particularly increased antenatal and neonatal care, and the rapid expansion of vaccination coverage. Maternal education gains are a second major factor, one clearly driven by public investments going back to the 1990s. Wealth accumulation is a third important factor, but one more difficult to link to specific policies or specific pathways, though there are strong indications of a leading role for growth in remittances as a driver of household income growth. Rapid improvements in sanitation—particularly the dramatic reduction in open defecation—are a fourth factor, one with a particularly strong association with maternal nutrition (body mass). Other factors—such as improved family planning outcomes and intergenerational transmission (maternal height)—generally played a much smaller role. Also of importance is that our models generally perform very well at explaining nutritional change over time, accounting for around 80 percent of the actual change in HAZ and stunting, for example.

The remainder of this paper is structured as follows. Section 2 gives some background on social and economic developments in Nepal in the 1990s and 2000s, as a means of identifying potential drivers of nutritional change and framing our hypotheses. Section 3 describes our data. Section 4 describes our methods. Section 5 presents our results, and section 6 concludes.

## 2. SOME BACKGROUND ON POTENTIAL DRIVERS OF NUTRITIONAL CHANGE IN NEPAL

Nepal is a Himalayan country of slightly more than 30 million people, characterized by a highly agrarian economy and predominantly Hindu society. Though Nepal is still traditional, the past two decades have seen tumultuous social, political, and economic change in the country (GoN and UN 2013). The 1990s saw economic and political liberalization, including a much more expanded role for the private sector and for civil society and nongovernmental organizations (NGOs) and substantial decentralization of service provision. By the turn of the century, civil society had become a major resource mobilizer at the grassroots level, and the state had been relegated to the role of facilitator and policy reformer. But despite solid if unspectacular economic growth and relatively rapid poverty reduction, high levels of inequality across the country's different regions and different social groups provided a catalyst for a Maoist insurgency (largely from 2000 to 2006) that resulted in 15,000 deaths and severe disruption to the economy. A peace agreement brokered in 2006 ended the conflict but resulted in a painfully slow transition to a new constitutional democracy. Nevertheless, as we discuss below, substantial social and economic gains were made during the 2000s, even during the civil war.

### Economic Growth

Nepal is a highly agrarian economy, though one diversely spread across three agroecologies (plains [*terai*], hills, and mountains), with a relatively small urban population substantially clustered in the Kathmandu valley. Though still poor and beset by conflict for much of the past decade, Nepal has made remarkable progress against poverty, with national poverty rates falling from 68 percent in 1995 to 25 percent in 2010. Three factors likely explain this.

First, despite modest growth in the domestic economy (per capita gross domestic product grew by just 2.5 percent per year during the 2000s), there was strong growth in workers' remittances. During the conflict around 300,000 Nepalese left the country every year to work in India and the Gulf states, and official remittances from these workers grew by around 150 percent. Survey-based estimates also suggest that remittance growth accounted for as much as half of the sizeable reduction in poverty rates during Nepal's conflict (Government of Nepal and World Bank 2006).

Second, growth in the agricultural sector—the largest employer and one in which the poor mostly work—was surprisingly robust during this period, growing at 3.8 percent per year from 2001 to 2011 (United Nations 2014).

Third, tourism receipts recovered strongly after the war, growing by around 250 percent from 2006 to 2011 (World Bank 2014).

A large existing literature on income growth and nutrition would suggest that Nepal's economic progress during this period is likely to have been a substantial driver of nutritional change, particularly of improvements in diets, and increased demand for education, health, and family planning services, all of which have been linked to improved nutrition outcomes (Haddad et al. 2003; Headey 2013; Smith and Haddad 2000).

### Education

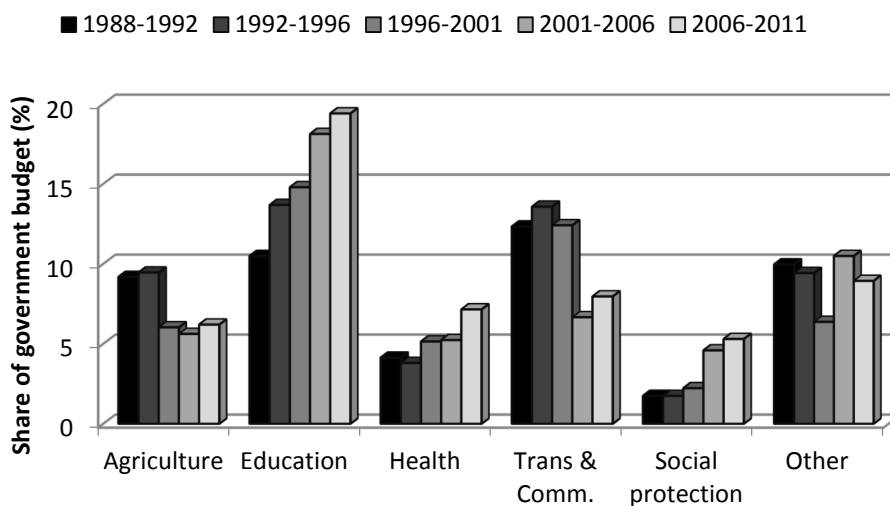
The economic reforms of the 1990s included a major effort to improve education levels in Nepal. The share of the government budget devoted to education rose steadily from around 10 percent in 1988–1992 to almost 20 percent in 2006–2011. Wealthier Nepalese have also been using private schools more, especially in recent years. As a consequence of these factors the youth literacy rate rose from slightly less than 50 percent in 1991 to 82 percent in 2011, while female youth literacy rates rose even faster, from 32 percent in 1991 to 77 percent in 2011 (World Bank 2010). A sizeable literature on parental education and child nutrition outcomes would suggest that gains in education have played an important part in

improving nutrition outcomes in Nepal (Burchi 2012; Desai and Alva 1998; Headey 2013; Thomas, Strauss, and Henriques 1991).<sup>2</sup>

### Health and Nutrition Interventions

Historically, Nepal’s health sector has suffered from underinvestment, especially in the provision of basic health services in what are often isolated rural communities (CBS 2005). Since the late 1990s, however, we have seen persistent reforms to the health sector in terms of both an increase in the health sector budget to around 7 percent of total public spending (Figure 2.1) and realignment toward primary care at the community level (GoH and UN 2013). In 1992 there were only 1,098 healthcare institutions in the country (hospitals, clinics, and health posts), but this number quadrupled to 4,439 by 2001–2002 (CBS 2005). On top of this the government established more than 15,000 primary healthcare outreach clinics staffed by volunteer health workers and maternal and child health workers who provided grassroots health services and advice, including nutritional advice. By the late 2000s there were some 50,000 volunteer health workers through the countryside (World Bank 2010). And from 2006 onward, the government took important steps to improve access to antenatal, neonatal, and postnatal care. The Aama Surakchhya Programme, in particular, operates throughout the country, providing free child delivery service and financial incentives to mothers, health workers, and health facilities. In 2011 the government extended this scheme to include payments to mothers for completing four antenatal care (ANC) visits, delivering in a health facility, and attending at least one postnatal care session.

**Figure 2.1 Trends in shares of the government budget by broad sectors**



Source: International Food Policy Research Institute (2014).

Note: Trans & Comm. = Transport and communications.

These various health-sector initiatives appear to have substantially increased access to a wide range of health services, including immunization, vitamin A supplementation, prenatal care, prenatal iron supplementation, medically attended births, postnatal care, and treatment of diseases, particularly diarrhea, malaria, and acute respiratory infections (Nepal, MOHP, New ERA, and ORC Macro 1997,

<sup>2</sup> As with wealth, however, the links are varied. Education may be associated with better care practices and greater nutritional knowledge and also with maternal empowerment, health service use, and better family planning outcomes. The literature is unclear about whether maternal and paternal education have equal effects, though the issue may well be highly context specific.

2002; Nepal, MOHP, New ERA, and ICF International 2007, 2012).<sup>3</sup> Overall, then, there are strong grounds to expect that health and nutrition interventions in Nepal have played an important role in the reduction of malnutrition, with previous research noting the importance of ANC visits in particular (Khanal, Sauer, et al. 2014; Khanal, Zhao, and Sauer 2014).

## **Family Planning**

Family planning interventions have a long history in Nepal, and the country managed to achieve sizeable reductions in fertility rates even prior to the beginning of our sample. However, from 2001 to 2011 fertility rates fell substantially, by around 0.8 children, while mean birth intervals increased by 0.7 years. Family planning interventions have been quite active in Nepal. In 2001 the Nepal Family Health Program was initiated. The program ran from 2001 to 2006 and focused on reducing fertility and protecting family health through increased use of quality family planning services and selected maternal and child health services. Similarly, Nepal Family Health Program II (2007–2012) continued and expanded these services.

However, it is by no means obvious that family planning interventions were the decisive factor in demographic changes during recent years. For one thing, desired fertility rates also declined steeply in Nepal, suggesting that income growth, education, and other attitudinal changes were important. Moreover, there is suggestive evidence that much of the decline in fertility observed in Nepal is due to out-migration of men (Khanal et al. 2013). Indeed, from 2001 to 2011 the percentage of women whose husbands were away from home increased from 21 to 32.

## **Sanitation and Water**

Despite ongoing challenges, Nepal has seen vast improvements in sanitation, largely through a decentralized collaboration between governments, international donors, and NGOs; the Nepal Water, Sanitation and Hygiene (WASH) coalition comprises no less than 60 organizations.<sup>4</sup> Following in the footsteps of Bangladesh (Kar 2003), an increasingly favored approach in Nepal since 2003 has been Community-Led Total Sanitation, an approach built around community-based behavioral change and the adoption of low-cost toilet facilities (Nepal, Ministry of Urban Development 2013).<sup>5</sup> Several international donors, including the Department for International Development, AusAid, UNICEF, and the European Union, have financed relatively large-scale WASH programs in various regions of the country. These efforts appear to have led to a substantial reduction in open defecation in Nepal. From 2001 to 2011 the percentage of households engaged in open defecation fell from 75.1 percent to 42.3 percent (Table 5.2). Open defecation has been shown to be very harmful for the growth of young children in India (Spears 2013; Spears, Ghosh, and Cumming 2013) and Bangladesh (Headey et al. 2014).

There were far more modest changes in water supply. Piped water rose from 35.4 percent to 48.3 percent during this period. Moreover, there is little strong evidence that water sources and child growth are strongly and consistently related, perhaps because piped water is a poor proxy for water quality, but also because of lack of information about how water is treated prior to consumption (Headey 2013).

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<sup>3</sup> One factor omitted from our analysis is road infrastructure, which is likely a very important determinant of access to health, education, and other services.

<sup>4</sup> Indeed, coordination of WASH activities is seen as one of the sector's main challenges (Nepal, Ministry of Urban Development 2013).

<sup>5</sup> Nepal has also invested substantially in school-based sanitation campaigns, which may be positively correlated with improvements in household sanitation for various reasons. However, school-based data are not recorded in the Demographic Health Survey.

## **Women's Empowerment**

As it is in other South Asian countries, gender inequality is regarded as a serious problem in Nepal. In the late 1990s women's education levels were well below men's, and DHS data reveal very low maternal involvement in household decisionmaking. Women's empowerment has been a crosscutting theme of many government and NGO projects and programs, however. But as we discuss below, measuring maternal empowerment is quite difficult (beyond the more specific and objective education and health variables). In this paper we use a mother's participation in household decisionmaking as an indicator of maternal empowerment, and this indicator does indeed show modest improvement during the past decade, but from a very low base.

### 3. DATA

We analyze three rounds of Nepal's DHSs (Nepal, MOHP, New ERA, and ORC Macro 2002; Nepal, MOHP, New ERA, and ICF International 2007, 2012): 2001, 2006, and 2011.<sup>6</sup> These surveys are almost ideally suited for our purposes insofar as they are nationally representative survey instruments that are highly consistent over time in their coverage of a wide array of nutrition-relevant indicators.

The dependent variables in this analysis include both maternal and child nutrition indicators. For children we primarily focus on HAZs for preschool children as measured against World Health Organization growth standards, which are described in de Onis et al. (2007) and WHO (2006). Linear growth is now widely regarded as the single most relevant indicator of overall nutrition, and the reduction in stunting (HAZs of two standard deviations or less) is the standard metric of nutritional success. However, several authors in the statistical epidemiology literature have persuasively argued against the analysis of dichotomous rather than continuous variables on the grounds that dichotomizing variables unnecessarily weakens the power of statistical tests (Royston, Altman, and Sauerbrei 2006; Weinberg 1995). In our case our pooled sample size is large enough to greatly reduce this concern, so we also analyze rates of moderate stunting ( $HAZ < -2$ ) and severe stunting ( $HAZ < -3$ ). However, since a substantial part of the Asian enigma may be a result of low birth weight (Ramalingaswami, Jonson, and Rohde 1997), we also analyze a subjective indicator of the child's size at birth, as reported by his or her mother. Specifically, we aggregate the "very small" and "small" categories into a single "born small" dummy variable. Previous research has shown that this indicator seems to be quite an effective predictor of more objective measures of birth weight (Alderman, Lokshin, and Radyakin 2011).

For maternal nutrition we focus primarily on BMI and also focus on whether a mother has low BMI as defined by scores lower than 18.5. Maternal height is essentially determined in childhood, so we do not use this indicator as a dependent variable but do include it as a control variable in all our regressions. Also note that we did not analyze anemia outcomes on the grounds that these indicators were available only in the 2006 and 2011 rounds. However, we do note that the prevalence of both maternal and child anemia fell significantly for mothers during these two rounds, from 38.6 to 33.6 percent.

Most of our explanatory variables—which are defined in Table 3.1—are straightforward inclusions in nutrition models, with a few exceptions.

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<sup>6</sup> A fourth round—1997—was available but was excluded from our analysis for two reasons. First, it was not possible to construct the asset index for 1997 because of the very limited number of variables in the relevant module of the 1997 survey. Second, there was no significant nutritional change between 1997 and 2001. Hence this round was superfluous for our decomposition analysis.

**Table 3.1 Definitions of variables**

Short name	Definition
HAZ	Height-for-age z score (HAZ) measured against World Health Organization (2006) norms
Stunting	HAZ < -2
Severe stunting	HAZ < -3
Small birth size	Sum small and very small size at birth, as reported by mothers
Low maternal BMI	Maternal body mass index (BMI) < 18.5
Asset index (1–10)	6-component index; see text and Appendix A for details
Maternal education (years)	Mother's years of education
Paternal education (years)	Father's years of education
4 or more ANC visits	Dummy = 1 if mother received 4 or more antenatal care (ANC) visits
Iron during pregnancy	Dummy = 1 if mother received iron supplements during pregnancy
Born in hospital (0/1)	Dummy = 1 if child was born in hospital or medical clinic
All vaccinations (0/1)	Dummy = 1 if child received LPG; polio (2 shots); diphtheria, pertussis, and tetanus (3 shots); and measles vaccines
Preceding birth interval (years)	Interval between birth of present child and any previous
Open defecation (% , village)	Percentage of households in a village without any latrine
Water—tubewell (0/1)	Dummy = 1 if household water was sourced from tubewell
Water source—piped (0/1)	Dummy = 1 if household water was sourced from pipes
Women's empowerment (0–1)	Equally weighted index of women's involvement in 4 household decisions
Maternal height (cm)	Mother's height (in centimeters)

Source: Authors' construction.

First, we followed Filmer and Pritchett (2001) in using a DHS asset index to proxy for household wealth. These and other authors have shown that these asset indexes are good proxies for household socioeconomic status in terms of sharing strong correlations with other welfare indicators, including child nutrition outcomes. Indeed, Headey et al. (2014) show that an asset index derived from a 2011 Bangladesh dataset predicts child growth outcomes marginally better than household expenditure. For the three DHS rounds in our analysis we use principal components analysis to construct an index comprising six indicators (see Appendix A for further details). These indicators, and their respective time-invariant factor loadings, were radio ownership (0.15), TV ownership (0.50), bicycle ownership (0.22), use of improved cooking fuel (kerosene, biogas, electricity; 0.46), basic flooring (-0.49), and household access to electricity (0.47). After applying these loadings as weights in the index, we then rescaled the index to vary between a minimum score of 0 and a maximum score of 10.

On the positive side we find that this relatively parsimonious index performs well in explaining nutrition outcomes (Appendix A) and is highly correlated with more sophisticated indexes based on a larger set of indicators that were available in the 2006 and 2011 rounds. However, one limitation is that this measure of household wealth contains several variables that are influenced by activities outside the home (for example, public electricity supply) and contains variables that might have direct effects on nutrition in addition to contributing to household wealth. For example, TVs and radios carry programs with prominent health and family planning messages (Nepal, MOHP, New ERA, and ICF International 2012). This implies that we should be cautious in inferring that the relationship between this asset index and wealth outcomes is entirely driven by changes in household wealth.

A second issue pertains to our own construction of the percentage of households in a village (DHS cluster) engaged in open defecation. While many previous studies measure this indicator at the household level, Spears (2013) points out that open defecation is a negative externality, especially since household members are essentially immune to the bacteria in their own waste. This implies that community-level indicators of open defecation are more relevant than household-level variables.

Finally, we construct a decisionmaking index for women as an indicator of women's empowerment. DHS asks a series of questions about whether a woman has a say in large household purchases, her own healthcare, the spending of money she has earned, and visits to relatives. We construct an index attaching equal weights to all four variables, with a score of 1 signifying involvement in all four decisions and 0 no involvement.



## 4. METHODS

We use linear regression models and linear probability models (LPMs) to assess the associations between nutrition outcomes (N) for a child  $i$  at time  $t$  and a vector of time-varying intermediate determinants (X), a vector of control variables (maternal height, child and maternal age dummies, location fixed effects;  $\mu_i$ ), and trend effects represented by a vector of year dummy variables (T). The vector of coefficients ( $\beta$ ) constitutes the set of parameters of principal interest. With the addition of a standard white noise term ( $\varepsilon_{i,t}$ ) we represent this relationship by equation 1:

$$N_{i,t} = \beta X_{i,k} + \mu_i + T + \varepsilon_{i,t}. \quad (1)$$

Equation 1 represents a standard reduced-form model in which nutrition outcomes are modeled as a function of “intermediate factors,” in the parlance of the well-known UNICEF (1990) framework.

Apart from the standard least squares assumptions, there are several misspecification issues to consider in estimating equation 1. First, we would ideally like to identify policy-driven (supply-side) determinants of nutrition outcomes, particularly in the domains of health, sanitation, and family planning outcomes. Appropriate control for household wealth and parental education would presumably take us a long way to purging the regression of demand-side factors that might simultaneously influence nutrition and the demand for health, sanitation, and family planning services, but such an assumption is impossible to test. Hence we emphasize that the evidence we generate on policy-relevant factors is admittedly circumstantial.

A second important assumption in equation 1 is that the model is linear. To that end we took two steps. First, we adopted a flexible specification of the time-invariant determinants including monthly dummy variables to capture the progressive growth-faltering process that malnourished populations undergo until around two years of age (Shrimpton et al. 2001). Second, we undertook nonparametric graphical analyses of all time-varying continuous variables to examine whether nonlinearities exist in their relationships with HAZs. There is minimal evidence of any significant nonlinearities, however (Figure B.3).

Equation 1 is used to answer the first of our two questions about the determinants of undernutrition in Nepal but also can be used to understand drivers of nutritional change over time. Under the assumption that the  $\beta$  coefficients are time-invariant,<sup>7</sup> and the error term has a mean of 0, the first difference of equation 1 between time 1 and time K is given by the following:

$$\Delta \bar{N}_{i,t} = \beta (\bar{X}_{t=K} - \bar{X}_{t=1})$$

where bars represent sample means.

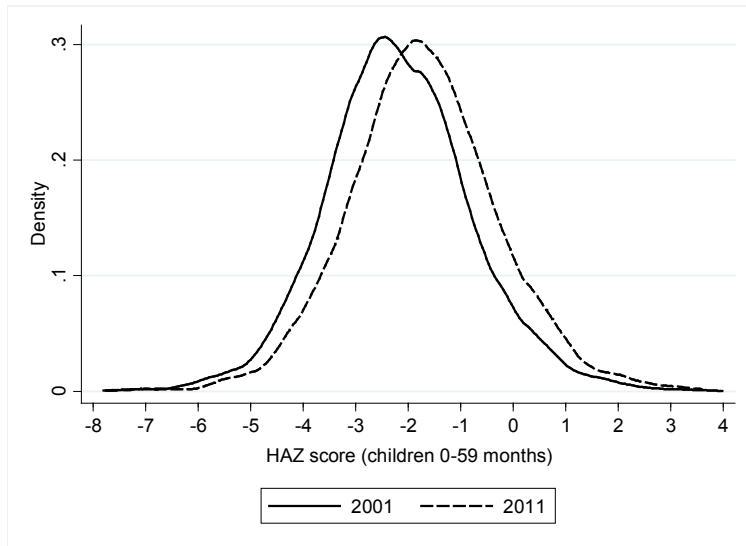
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<sup>7</sup> If, however, the coefficients are time varying, the Oaxaca-Blinder decomposition can be used break up the estimated change in the dependent variable into changes in endowment, changes in coefficients, and interactions between the two (see Jann 2008 for a detailed explanation of this approach). In contrast to using all three rounds of data, the Oaxaca-Blinder decomposition uses only the first and last rounds and tests for systematic coefficient differences between the two rounds. We opt for the linear decomposition described in the text because our preferred regression models tend to perform poorly in the 2011 round when the survey measured nutrition outcomes for only every second household. Thus, we suspect that the much smaller sample size in this round produces this instability, rather than any genuine change in the effects (coefficients) of the explanatory variables. If there is a high degree of parameter stability across time then the two decomposition techniques are equivalent.

## 5. REGRESSION ANALYSIS

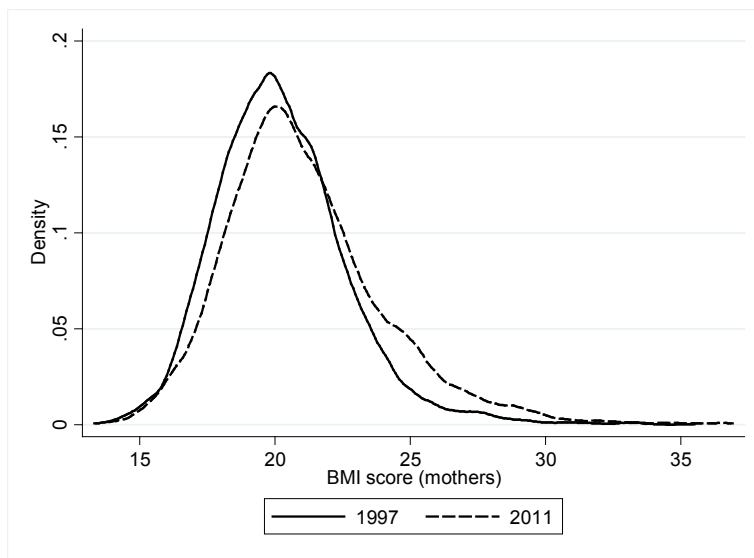
We begin our analysis with some basic descriptive statistics, with a view toward understanding patterns and trends in nutritional change over time. Figures 5.1 and 5.2 show kernel density estimations of the distribution of child HAZs and maternal BMIs, respectively, for both 2001 and 2011. Figure 5.1 suggests an almost parallel shift of the entire distribution of HAZs—in effect, a distribution-neutral improvement in child growth outcomes. Figure 5.2 shows a somewhat different pattern for maternal BMI, with more improvement at the lower end of the tail but also a reasonably large increase in the number of women with relatively high BMIs, including pre-obesity ( $25 < \text{BMI} < 30$ ).

**Figure 5.1 Shifts in the distribution of height-for-age z scores (HAZs), 2001 to 2011**



Source: Kernel density estimates from the 2001 (Nepal, MOHP, New ERA, and ORC Macro 2002) and 2011 (Nepal, MOHP, New ERA, and ICF International 2012) Demographic Health Surveys.

**Figure 5.2 Shifts in the distribution of maternal body mass indexes (BMIs), 2001 to 2011**



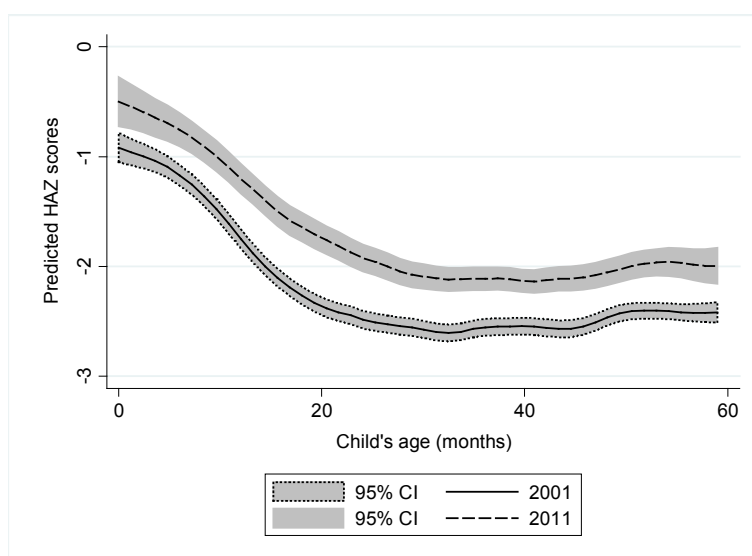
Source: Kernel density estimates from the 2001 (Nepal, MOHP, New ERA, and ORC Macro 2002) and 2011 (Nepal, MOHP, New ERA, and ICF International 2012) Demographic Health Surveys.

In Figure 5.3 we look at predicted HAZs by child's age, in the spirit of the age-specific plots pioneered by Shrimpton et al. (2001). Such plots inform two important characteristics of undernutrition in any given context:

1. The extent to which undernutrition is the result of small size at birth, which in turn would imply that maternal malnutrition is an important constraint
2. The extent to which undernutrition is the result of postnatal growth faltering, which tends to be most acute from around 6 months of age to around 24 months of age (age 6 months roughly coincides with the introduction of solid foods and liquids other than breast milk and with increased mobility and hence exposure to disease)

Strikingly, we observe fairly uniform improvement in child growth outcomes at all ages, implying that most of the improvement in undernutrition in Nepal is the result of larger birth sizes and hence improved maternal nutrition. There is, however, some small flattening out of the growth-faltering process from 6 months to 24 months of age, which may be attributable to improved diets or other care practices, such as vaccinations and sanitation. Strikingly, both results are quite similar to our analysis of Bangladesh in a companion paper to the present study. This suggests that much of the improvement in undernutrition in South Asia may initially need to come from improvements in birth size and hence in maternal nutrition.

**Figure 5.3 Shifts in height-for-age z scores (HAZs), by child's age, from 2001 to 2011**



Source: These are local polynomial smoothing predictions with 95% CIs estimated from the 2001 (Nepal, MOHP, New ERA, and ORC Macro 2002) and 2011 (Nepal, MOHP, New ERA, and ICF International 2012) Demographic Health Surveys.  
 Note: CI = confidence interval.

Table 5.1 focuses on trends in the various child and maternal nutrition indicators analyzed below. As noted in the Introduction, nutritional change was impressive on multiple fronts. Mean HAZs improved by more than half a standard deviation from 2001 to 2011. Stunting fell from 56.6 percent to 40.0 percent during the same period, while severe stunting fell from 24.2 percent to just 14.6 percent. The prevalence of babies reported to be small at birth declined more marginally, by just 3 percentage points. Maternal BMI also showed more uneven change, with the prevalence of low BMI mothers falling during 2006–2011, albeit quite quickly, from 25.3 percent to 19.6 percent.

**Table 5.1 Trends in means for various maternal and child nutrition indicators**

Year	Mean HAZ score	Stunting (%)	Severe stunting (%)	Born small (%)	Low maternal BMI (<18.5) (%)
2001	-2.17	56.6	25.3	20.7	24.8
2006	-1.90	49.6	18.7	18.7	25.3
2011	-1.66	40.1	14.60	17.6	19.6
<b>Changes from 2001 to 2011</b>					
Absolute	0.51	-16.5	-10.7	-3.1	-5.2
Percentage	-23.4	-29.2	-44.2	-12.0	-20.1

Source: Weighted means are calculated from various rounds of the Demographic Health Surveys (Nepal, MOHP, New ERA, and ORC Macro 2002; Nepal, MOHP, New ERA, and ICF International 2007, 2012).

Notes: HAZ = height-for-age z score; BMI = body mass index.

Table 5.2 looks at trends in the explanatory variables in our models. Consistent with section 2, Nepal has clearly witnessed major economic and social changes in past decades. The mean asset index score rose significantly, even during the conflict (2001–2006). Women’s education improved rapidly from a low base—indeed, more rapidly than men’s, though maternal education still lags well behind paternal education. Health changes were even more revolutionary (see Appendix B for additional health results). The mean number of ANC visits more than doubled, and hospital births increased by almost 300 percent from a very low base, while the percentage of children older than 6 months increased from slightly more than half to more than two-thirds. Demographic changes were also sizeable, with a significant decrease in fertility (measured in our models as birth order) and increase birth intervals, improvements which have previously been linked with nutrition outcomes (Behrman 1988; Horton 1988; Rutstein 2005). The prevalence of open defecation declined quickly, from 75.1 to just 42.3 percent. There were more modest changes in water supply, with an increase in piped water of 13 percentage points. Finally, there was a marked change in women’s decisionmaking, though by the end of the sample the average woman had a say in only one of four possible decisions, suggesting gender inequality is still a significant problem.

**Table 5.2 Trends in means for key explanatory variables, 2001, 2006, and 2011**

Year	Asset index (1–10)	Maternal education (years)	Paternal education (years)	4 or more antenatal care visits (%)	Iron during pregnancy (%)	Born in hospital (0/1) (%)
2001	2.1	1.5	4.3	8.5	22.1	9.2
2006	3.8	2.6	5.3	16.0	58.3	19.3
2011	5.1	3.7	5.8	28.6	78.5	36.3
Change	3.0	2.3	1.5	20.1	56.4	27.0
% change	143.0	155.0	33.6	236.5	255.2	292.7
Year	All vaccinations (0/1) (%)	Preceding birth interval (years)	Open defecation (% of village)	Water source—tubewell (%)	Water source—piped (%)	Women’s decisionmaking (%)
2001	52.4	3.9	75.1	37.7	35.4	12.1
2006	64.5	4.2	56.9	41.5	36.2	18.7
2011	69.8	4.6	42.3	31.4	48.3	23.5
Change	17.4	0.7	-32.8	-6.3	12.9	11.4
% change	33.1	16.5	-43.7	-16.7	36.4	94.2

Source: Weighted means are calculated from various rounds of the Demographic Health Surveys (Nepal, MOHP, New ERA, and ORC Macro 2002; Nepal, MOHP, New ERA, and ICF International 2007, 2012).

We now turn to our basic regression results (Table 5.3). Column 1 reports an ordinary least squares model of HAZs against the set of explanatory variables listed in Table 5.2 as well as basic controls for age, location, and birth order effects (which are omitted for the sake of brevity). A one-unit change in the 0–10-scale asset index predicts a 0.04 standard deviation change in HAZs, suggesting that the growth gap between children from the poorest and richest households is about 0.40 standard deviation.

**Table 5.3 The determinants of child growth, birth size, and maternal body mass index in a pooled regression model**

Regression number	1	2	3	4	5
Dependent variable	Height-for-age z score	Stunting	Severe stunting	Small size at birth	Low maternal BMI
Estimator	OLS	LPM	LPM	LPM	LPM
Asset index (1–10)	0.042*** (0.007)	–0.014*** (0.003)	–0.006*** (0.002)	–0.003 (0.002)	–0.009*** (0.003)
Maternal education (years)	0.028*** (0.005)	–0.007*** (0.002)	–0.003** (0.001)	–0.004** (0.002)	–0.002 (0.002)
Paternal education (years)	0.008** (0.004)	–0.001 (0.002)	–0.003*** (0.001)	–0.002 (0.001)	–0.002 (0.002)
4 or more antenatal care visits	0.092** (0.036)	–0.036** (0.014)	–0.008 (0.010)	–0.035*** (0.012)	–0.005 (0.014)
Iron during pregnancy	–0.029 (0.030)	0.004 (0.012)	–0.011 (0.01)	–0.030*** (0.010)	0.028** (0.013)
Born in hospital (0/1)	0.200*** (0.040)	–0.062*** (0.015)	–0.017* (0.01)	–0.011 (0.012)	0.005 (0.014)
All vaccinations (0/1)	0.110*** (0.039)	–0.031** (0.016)	–0.045*** (0.014)		
Preceding birth interval (years)	0.031*** (0.009)	–0.010*** (0.004)	–0.006** (0.003)	0.004 (0.003)	
Open defecation (% village)	–0.151** (0.069)	0.066*** (0.024)	0.036* (0.02)	–0.002 (0.021)	0.090*** (0.023)
Water—tubewell (0/1)	0.121*** (0.045)	–0.056*** (0.017)	–0.028** (0.012)	–0.026* (0.015)	0.124*** (0.019)
Water source—piped (0/1)	–0.032 (0.035)	0.002 (0.014)	0.003 (0.010)	–0.002 (0.012)	–0.027** (0.013)
Women's empowerment (0–1)	–0.006 (0.037)	0.009 (0.015)	0.007 (0.012)	0.01 (0.013)	–0.034** (0.014)
Maternal height (centimeters)	0.055*** (0.002)	–0.018*** (0.001)	–0.012*** (0.001)	–0.003*** (0.001)	0.004*** (0.001)
R-squared	.316	.217	.139	.04	.101
N	9,341	9,341	9,858	9,858	7,344

Source: Authors' estimates.

Note: OLS = ordinary least squares; LPM = linear probability model. Clustered robust standard errors are reported in parentheses. The regressions include a number of omitted controls, including period fixed effects, regional and agroecological fixed effects for 13 groups, an urban dummy, district-level population density, birth order dummies, dummy variables for religion and caste, month-specific child age dummy variables (except in the maternal body mass index regression), dummy variables for various categories of maternal age, and Demographic Health Survey round dummy variables. See Table 3.1 for definitions of variables. \*Significant at the 10 percent level. \*\*Significant at the 5 percent level. \*\*\*Significant at the 1 percent level.

Maternal education has a commensurately large effect. The difference between a mother's having no education and six years of education (completing primary) is about 0.17 standard deviation and about 0.34 standard deviation for completing secondary school. However, the impact of paternal education is about one-quarter the impact of maternal education and is significant at only the 10 percent level.

Receiving at least four ANC visits predicts a 0.09 standard deviation improvement in HAZs, but iron supplements for mothers during pregnancy has no significant effect on HAZs. Birth in a hospital is associated with almost 0.20 standard deviation improvement. Receiving all vaccinations also has a relatively large impact of 0.10 standard deviation.

Birth intervals have a significant but relatively modest effect, but birth order effects are insignificant. Open defecation at the village level has a moderately large effect. Moving from a situation of 50 percent open defecation to 0 percent would improve HAZs by about 0.07 standard deviation.<sup>8</sup> Water supplies yield the potentially surprising result that tubewells improve child growth outcomes, while piped water relative to more basic sources leads to no improvement. The maternal decisionmaking index has no significant effect on child growth scores. Maternal height—an intergenerational effect rather than any policy-related impact—has a relatively large impact: every extra centimeter of height raises child HAZ by 0.05 standard deviation.

Qualitatively, many—but not all—of these basic results for HAZs carry over to the LPMs estimated for stunting (regression 2) and severe stunting (regression 3), though the magnitudes of the effects vary between stunting and severe stunting. The asset index, maternal education, ANC visits, hospital births, birth intervals, and open defecation all have larger marginal effects on stunting than severe stunting. In contrast, paternal education significantly affects severe stunting but has no effect on stunting, and vaccinations seem to have a somewhat stronger association with severe stunting than stunting. Consistent with the generally larger marginal effects in the stunting model, the explanatory power of the stunting model is substantially larger than the severe stunting model.

Regression 4 uses LPM to look at the small size at birth variable, as reported by mothers. The explanatory power of this regression is relatively weak, and only a few variables are significant (perhaps because the self-reported data are quite noisy and potentially biased). Maternal education has a highly significant marginal effect—a woman with 12 years of education has a 5 percent smaller chance of giving birth to an undersized child. Four or more ANC visits is also significant and predicted to reduce small birth size by 3.50 percentage points. And in contrast to subsequent child growth outcomes, maternal iron supplementation reduces the risk of small size at birth by 3 percentage points. Water sourced from a tubewell also has a significant marginal effect at the 10 percent level, predicting a 2.6-point reduction in the risk of small size at birth.

In regression 5 we turn to an LPM of low maternal BMI. As expected, household assets predict reductions in BMI incidence: the difference between the richest and poorest households is about 9 percentage points. Somewhat surprisingly, neither maternal nor paternal education has significant effects. Health service access is generally not associated with maternal BMI either, although iron supplementation during pregnancy has an unexpected positive sign, albeit with a small marginal effect. More substantive is the large positive impact of open defecation at the village level. A woman in a village in which open defecation is universal is 9 percent more likely to be underweight than a woman in a village in which open defecation has been eradicated. Water sourced from tubewells also has a large impact but has the opposite sign relative to previous regressions: tubewells increase the risk of a mother's being underweight by 12 percentage points, which is a large marginal effect. Moreover, piped water now reduces the risk of a mother's being underweight, although the effect is small. Finally, although maternal decisionmaking was insignificant in all the child-level regressions, it bears a statistically significant association with low maternal BMI, albeit with quite a small marginal effect. Moving from a situation of a woman's not being involved in any of the four decisions to being involved in all four results in only a 3.4-point decrease in

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<sup>8</sup> Like Spears (2013) and Headey et al. (2014), we found some evidence that the negative impacts of open defecation are amplified by population density or urban location. However, these impacts were generally not very strong.

the risk of being underweight. Admittedly, better indicators of female empowerment might yield stronger results.

Table 5.2 constitutes our core set of regressions, but we also engaged in a series of robustness tests.

First, we used quantile regressions as an alternative means of exploring whether some factors are more important at the lower end of the distributions of HAZs or stunting scores. The advantage of quantile regressions is that they allow us to explain variation around points of interest at the lower end of the HAZ or BMI distributions without having to resort to dichotomizing continuous variables.<sup>9</sup> Results reported in Appendix C suggest that this approach—estimated at both the 25th and 50th quantiles—yields results similar to those in Table 5.3.

Second, we estimated the models in Table 5.3 with the inclusion of district fixed effects. This made virtually no difference to any of the results, though it slightly altered the coefficients and standard errors attached to village-level open defecation (unsurprisingly, since only a handful of villages are measured for each district).

Third, we used a bivariate correlation analysis to examine the stability of the relationships between dependent and independent variables over time (Table 5.4 provides an example for HAZs).<sup>10</sup> For those variables that were significant in the regression results reported in Table 5.2 we find little evidence of large changes in these relationships over time. We therefore conclude that there is little indication of substantial changes in these relationships over time, which justifies a linear decomposition analysis based on coefficients from the pooled model in Table 5.3.

**Table 5.4 Bivariate correlations between height-for-age z scores and explanatory variables, year by year**

<b>Variable</b>	<b>2001</b>	<b>2006</b>	<b>2011</b>	<b>All rounds</b>
Asset index (1–10)	0.19	0.25	0.23	0.25
Maternal education (years)	0.17	0.26	0.25	0.25
Paternal education (years)	0.16	0.20	0.20	0.19
4 or more antenatal care visits	0.12	0.14	0.13	0.15
Iron during pregnancy	0.16	0.24	0.20	0.23
Born in hospital (0/1)	0.13	0.21	0.24	0.21
All vaccinations (0/1)	–0.12	–0.16	–0.22	–0.13
Preceding birth interval	0.07	0.12	0.14	0.12
Open defecation (% of village)	–0.11	–0.17	–0.17	–0.17
Water source—tubewell (0/1)	0.11	0.08	0.11	0.10
Water source—piped (0/1)	–0.08	0.00	–0.04	–0.03
Women’s decisionmaking (0–1)	0.01	–0.07	–0.02	–0.01
Maternal height (centimeters)	0.22	0.25	0.23	0.24

Source: Authors’ estimates.

<sup>9</sup> Two recent applications of quantile regressions in the nutrition literature are Block, Masters, and Bhagowalia (2012) and Srinivasan, Zanello, and Shankar (2013).

<sup>10</sup> Multivariate tests round by round are not sensible given the complex formulation of our model (particularly the combination of monthly child age effects, maternal effects, and regional effects) and the relatively small sample size of some rounds of the data. In particular, 2011 contains slightly more than 2,000 observations.

## 6. DECOMPOSITION ANALYSIS

We now use the results from Tables 5.1, 5.2, and 5.3 to analyze the predicted sources of nutritional change over time, based on equation 2 in section 3. The results are reported in Table 6.1. To see how these figures are derived, consider the second row of column 2 of Table 6.1, which reports the predicted change in HAZs, which is the mean change in assets from 2001 to 2011 multiplied by the marginal effect of assets on HAZs from regression 1 of Table 5.2. This calculation suggests that improvements in assets from 2001 to 2011 resulted in a 0.13 standard deviation increase in child HAZs. In addition to the large impact of asset accumulation, we observe sizeable contributions from maternal education (0.06), health (particularly hospital births), reductions in open defecation, and maternal height. The bottom of Table 5.3 also sheds light on the explanatory power of these decompositions. For HAZ the model predicts a 0.40 standard deviation improvement, as opposed to an actual 0.51 HAZ improvement, which suggests the decomposition explains around 80 percent of the actual change observed from 2001 to 2011.

**Table 6.1 Decomposing predicted changes in nutrition outcomes, 2001 to 2011**

Dependent variable	Height-for-age z score	Stunting (%)	Severe stunting (%)	Small size at birth (%)	Low maternal body mass index (%)
Asset index (1–10)	0.13	–4.2	–1.8	–0.9	–2.7
Mother’s education (years)	0.06	–1.5	–0.7	–0.9	
Father’s education (years)	0.01		–0.5	0.0	
4 or more antenatal care visits	0.02	–0.7		–0.7	
Iron during pregnancy				–1.7	
Born in hospital	0.05	–1.7	–0.5	0.0	
All vaccinations	0.02	–0.5	–0.8	0.0	
Preceding birth interval	0.02	–0.7	–0.4	0.0	
Open defecation	0.05	–2.2	–1.2	0.0	–3.0
Water source—tubewell (%)	–0.01	0.4	0.2	0.2	–0.8
Water source—piped					–0.3
Mother’s decisionmaking (%)					–0.4
Mother’s height	0.05	–1.6	–1.1	–0.3	
Predicted nutritional change	0.40	–13	–7	–4	–5
Actual nutritional change	0.51	–17	–11	–3	–5
Explanatory power of model (%)	79.3	77.7	62.2	138.1	100.6

Source: Authors’ estimates.

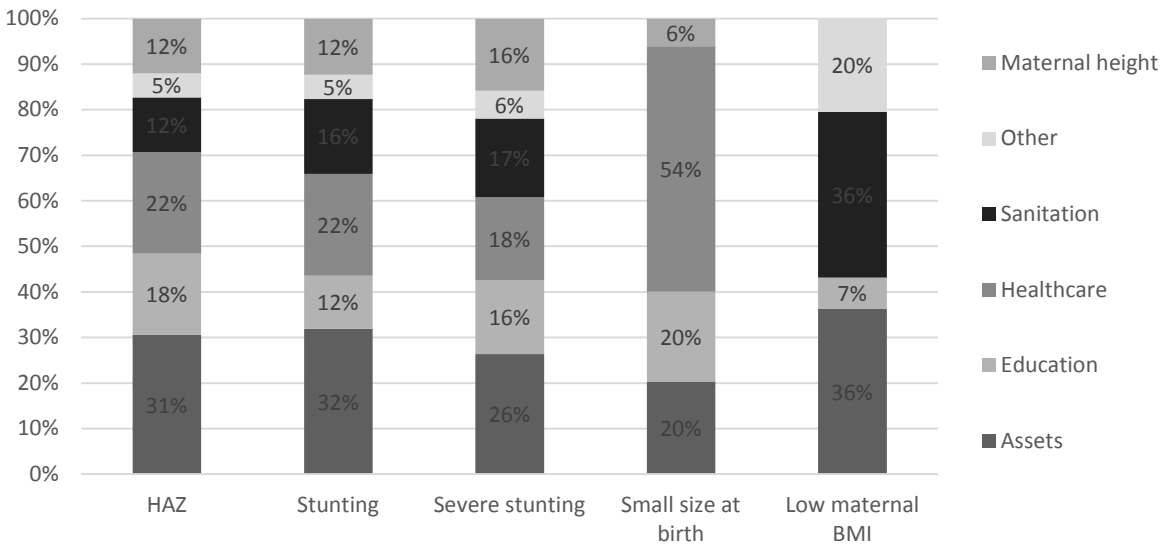
The patterns for stunting are quite similar. Asset accumulation alone accounts for a 4.2-point reduction in stunting, but health improvements and reductions in open defecation make sizeable contributions. There are similar patterns for severe stunting, but the model in this case explains only 62.2 percent of the actual change in stunting, consistent with the lower *R*-squared observed for the corresponding regression model in Table 5.3. For small size at birth we find a different story, with antenatal iron supplementation easily the most important factor, followed by asset accumulation and improvements in maternal education. For this variable the model explains 138 percent of the observed change, although the observed change is relatively small and pertains to a self-reported variable that may not be accurately capturing trends in birth size over time. Finally, the relatively modest changes in the



prevalence of underweight mothers are largely accounted for by reductions in open defecation and asset accumulation.

Figure 6.1 graphically portrays the contributions of different factors at a more aggregated level. Across the postnatal child growth categories asset accumulation is generally the largest driver of nutritional change. Improvements in healthcare, maternal education, and sanitation constitute a second set of factors that make sizeable contributions, followed by the intergenerational effect of maternal height. For small size at birth, iron supplementation appears to be the most important factor. Changes in low maternal BMI prevalence also appear to be much more affected by infrastructure, particularly sanitation. Overall, though, the drivers of nutritional change in Nepal have been quite diverse.

**Figure 6.1 Contributions to predicted nutritional change by nutrition indicator**



Source: Authors' estimates.

Note: HAZ = height-for-age z score; BMI = body mass index.

## 7. CONCLUSIONS

This paper sought to understand rapid improvements in maternal and child nutrition in what is undeniably one of the most impressive nutritional success stories of recent decades. Despite large-scale conflict and political instability, Nepal achieved reduced stunting prevalence by 1.8 points per year from 2001 to 2011. This analysis suggests that a number of factors contributed to this success.

First, we find that much of the improvement in child nutrition in Nepal seems to stem from improvements in birth size, with only a modest improvement in postnatal nutrition trajectories. This is consistent with a companion paper examining another unheralded nutrition success story, Bangladesh, in which the authors find a large improvement in birth size.

Second, asset accumulation emerges as an important factor across all five nutritional indicators. Section 2 links these material improvements to emigration and remittances, solid growth in the agricultural sector, and the strong recovery of tourism receipts after 2006.

Third, consistent with many other studies, educational improvements played an important role. Specifically, though, we find only maternal education contributes to improved child nutrition outcomes. On this front, Nepal still has some way to go to achieve gender parity in education levels, despite considerable catch-up in girls' schooling during the past two decades.

Fourth, quite revolutionary improvements in access to healthcare have played a large role in Nepal, with potentially important lessons for other developing countries. Major government programs have explicitly targeted ambitious improvements in antenatal, neonatal, and postnatal care. Particularly impressive are the dramatic improvements in iron supplementation and ANC more generally and the significant financial incentives used to get women and medical facilities to deliver more children in hospitals.

Fifth, Nepal has achieved sizeable gains in sanitation, specifically in the reduction of open defecation. While the DHS data cannot be used to distinguish the sources of this change, the sizeable uptake of Community-Led Total Sanitation campaigns in Nepal suggests this may have been an important factor underlying these greatly improved sanitation outcomes. It is also notable that improved sanitation seems to have driven sizeable improvements in maternal as well as child nutrition. Future research could also assess the importance of this intervention for reducing diarrhea incidence, which is the leading cause of child mortality in Nepal.

Finally, future research could aim to more qualitatively understand Nepal's success story, in the vein of Mejía Acosta and Haddad (2014), Heaver and Kachondam (2002), and others. The nutrition community typically distinguishes between nutrition-sensitive and nutrition-specific interventions. Impressionistically, we suspect this line is blurred somewhat in Nepal, where it appears that nutrition largely has been perceived as one part of a broader focus on improving maternal and child health outcomes, and health outcomes as one part of an even broader agenda of social, political, and economic change. But arguably it is only this kind of broad-based development that can achieve genuinely rapid nutritional improvements in highly underdeveloped contexts.

## APPENDIX A: CONSTRUCTION OF AN ASSET INDEX

One limitation of our analysis is that we were available to construct only a fairly simple asset index across the various rounds of the Demographic Health Survey using principal components analysis, following Filmer and Pritchett (2001). Only six “asset” indicators were available for 2001, 2006, and 2011. These assets, and their respective factor loadings, were radio ownership (0.15), TV ownership (0.50), bicycle ownership (0.22), use of improved cooking fuel (kerosene, biogas, electricity; 0.46), basic flooring (–0.49), and household access to electricity (0.47).

Despite being a relatively parsimonious index, it appears that relatively little information is lost by using a 6-indicator index relative to the 9-component and 18-component indexes. The correlations between the 6-component index and the other two asset indexes are .9 and greater, and the 6-component index does as well in predicting height-for-age *z* scores as any of the other indexes. Moreover, although one might expect that the 6-component index is not as good at predicting differences at upper ends of the wealth distribution, we find no evidence of this (Figure A.1).

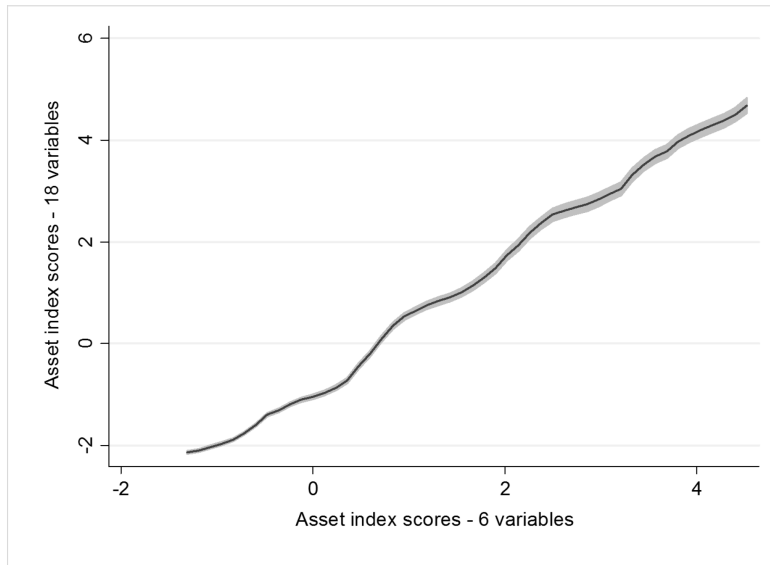
However, one inherent limitation of this index is that some of the components of the index may have effects on nutrition outcomes that are independent of wealth mechanisms. For example, cooking fuels may affect children’s susceptibility to acute respiratory infections, or radios and TVs may be important for receiving nutrition, health, and family planning messages. Another problem may be that some components of this index do not reflect household wealth so much as public investment in infrastructure, particularly electricity, which Figure 5.1 suggests was a major sources of total change in the asset index from 2001 to 2011.

**Table A.1 Correlations between height-for-age *z* scores (HAZs) and three asset indexes with different numbers of components**

	HAZ	6 components	9 components	18 components
HAZ	—			
6 components	.24	—		
9 components	.25	.94	—	
18 components	.26	.90	.93	—

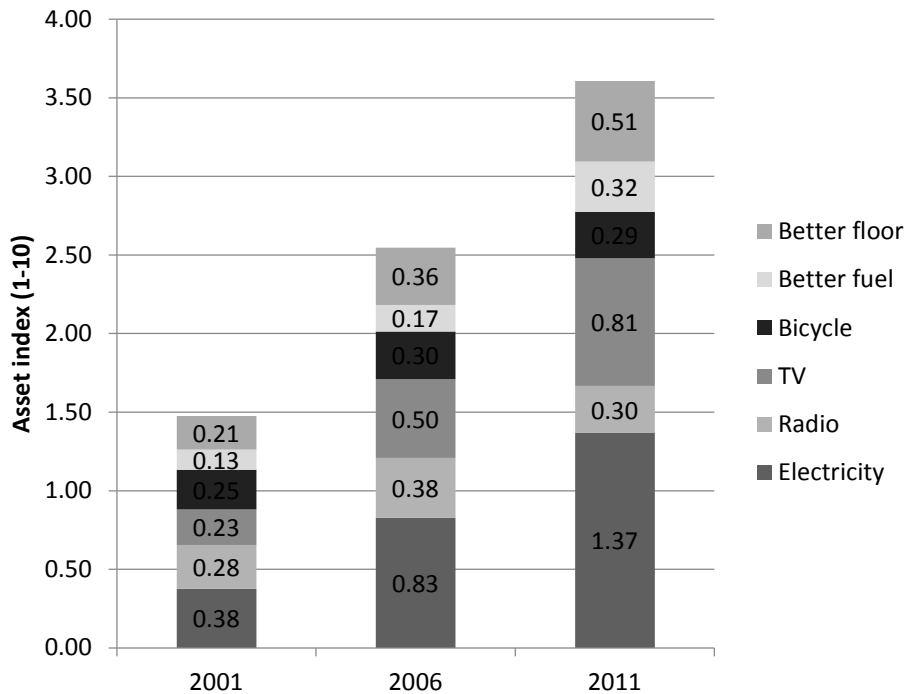
Source: Authors’ estimates from various rounds of the Nepal Demographic Health Survey (Nepal, MOHP, New ERA, and ORC Macro 2002; Nepal, MOHP, New ERA, and ICF International 2007, 2012).

**Figure A.1 The relationship between the 6-component asset index and the 18-component asset index**



Source: Authors' LOWESS estimates from the 2011 rounds of the Demographic Health Survey (Nepal, MOHP, New ERA, and ICF International 2012).

**Figure A.2 Sources of change in the 6-component asset index**



Source: Authors' estimates from various rounds of the Nepal Demographic Health Survey (Nepal, MOHP, New ERA, and ORC Macro 2002; Nepal, MOHP, New ERA, and ICF International 2007, 2012).

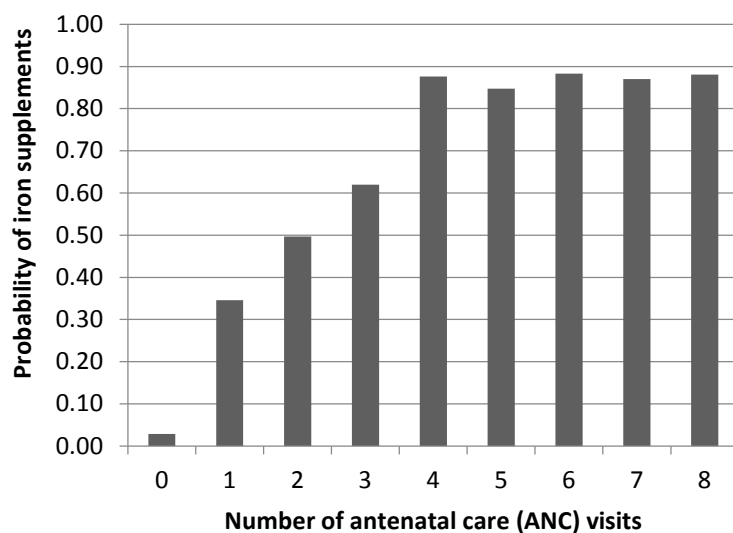
## APPENDIX B: ADDITIONAL DESCRIPTIVE STATISTICS

**Table B.1** Summary statistics for key explanatory variables

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Asset index (1–10)	16,994	2.25	2.76	0.01	10.00
Maternal education (years)	18,017	2.38	3.62	0.00	14.00
Paternal education (years)	17,840	5.08	4.11	0.00	14.00
Number of antenatal care visits	12,983	2.46	2.29	0.00	8.00
Born in hospital (0/1)	18,017	0.20	0.40	0.00	1.00
All vaccinations (0/1)	18,017	0.62	0.49	0.00	1.00
Birth order	18,017	2.92	2.02	1.00	15.00
Preceding birth interval	17,997	4.22	2.16	0.75	7.00
Open defecation (% of village)	18,017	0.60	0.35	0.00	1.00
Water source—tubewell (0/1)	17,002	0.36	0.48	0.00	1.00
Water source—piped (0/1)	17,002	0.39	0.49	0.00	1.00
Women’s empowerment index (0–1)	17,966	0.17	0.32	0.00	1.00
Maternal height (centimeters)	15,219	150.62	5.40	105.90	185.80

Source: Authors’ estimates from various rounds of the Nepal Demographic Health Survey (Nepal, MOHP, New ERA, and ORC Macro 2002; Nepal, MOHP, New ERA, and ICF International 2007, 2012).

**Figure B.1** The probability of a mother’s receiving iron supplements by the number of antenatal care visits



Source: Authors’ estimates from various rounds of the Nepal Demographic Health Survey (Nepal, MOHP, New ERA, and ORC Macro 1997, 2002; Nepal, MOHP, New ERA, and ICF International 2007, 2012).

**Table B.2 Trends in health inputs and outcomes in Nepal, 1996 to 2011**

<b>Variable</b>	<b>1996</b>	<b>2001</b>	<b>2006</b>	<b>2011</b>
<u>Antenatal care</u>				
Mothers with at least 1 visit (%)	41.3	48.5	72.2	85.0
Number of visits	1.20	1.57	2.50	3.63
4 visits or more (%)	6.3	9.0	16.0	30.6
Iron supplements (%)	10.8	15.6	41.3	61.5
Tetanus shot (%)	43.2	52.8	71.2	82.1
Blood pressure taken (%)	Not available	60.9	78.5	87.3
Blood work done (%)	Not available	27.5	27.4	44.8
Urine tests done (%)	Not available	29.2	31.4	54.8
<u>Neonatal Care</u>				
Born in health facility (%)	7.8	9.4	17.2	36.1
Assisted by a doctor (%)	5.8	8.2	9.4	17.1
Assisted by midwife/nurse (%)	8.8	11.5	20.7	40.3
<u>Child health inputs and outcomes</u>				
Child received all vaccinations (%)	30.1	53.4	64.4	70.0
Child received vitamin A (%)	25.7	74.0	86.3	79.5
Diarrhea in past 2 weeks (%)	57.6	40.4	24.3	27.0
Fever in past 2 weeks (%)	40.7	31.5	18.1	18.0
Cough in past 2 weeks (%)	48.1	40.4	18.3	20.8
Under-5 mortality rate (per 1,000)	139	108	79	62

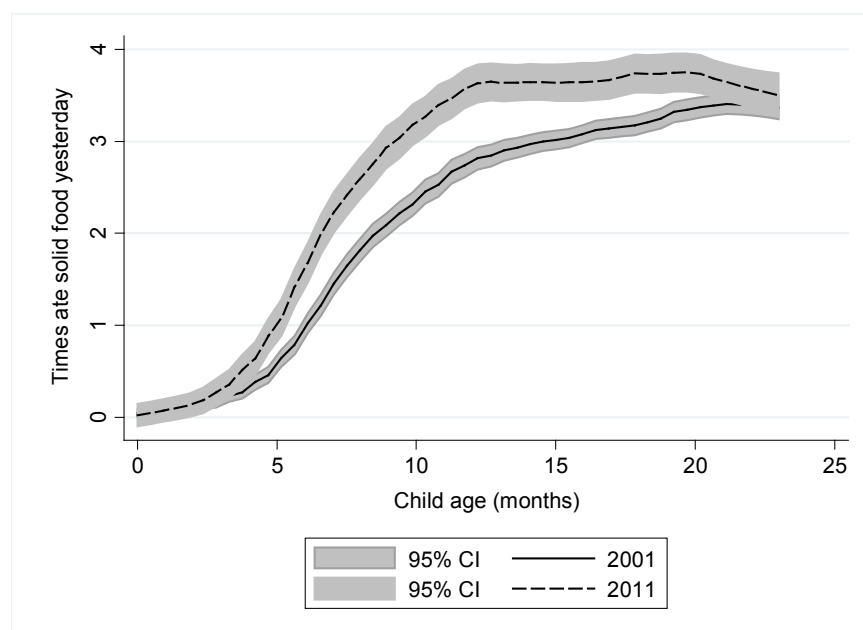
Source: Authors' estimates from various rounds of the Nepal Demographic Health Survey (Nepal, MOHP, New ERA, and ORC Macro 1997, 2002; Nepal, MOHP, New ERA, and ICF International 2007, 2012).

**Table B.3 Trends in health service utilization by asset index quartiles, 2001 to 2011 (in percentages)**

Variable	Year	Asset quartiles			
		Quartile 1	Quartile 2	Quartile 3	Quartile 4
4 antenatal care visits	2001	2.9	5.0	17.9	28.5
	2011	12.8	16.9	30.0	51.5
Medical birth	2001	3.0	5.0	15.0	35.0
	2011	12.0	20.0	39.0	64.0
All vaccines	2001	46.0	59.0	57.0	62.0
	2011	63.0	70.0	71.0	73.0

Source: Authors' estimates from various rounds of the Nepal Demographic Health Survey (Nepal, MOHP, New ERA, and ORC Macro 1997, 2002; Nepal, MOHP, New ERA, and ICF International 2007, 2012).

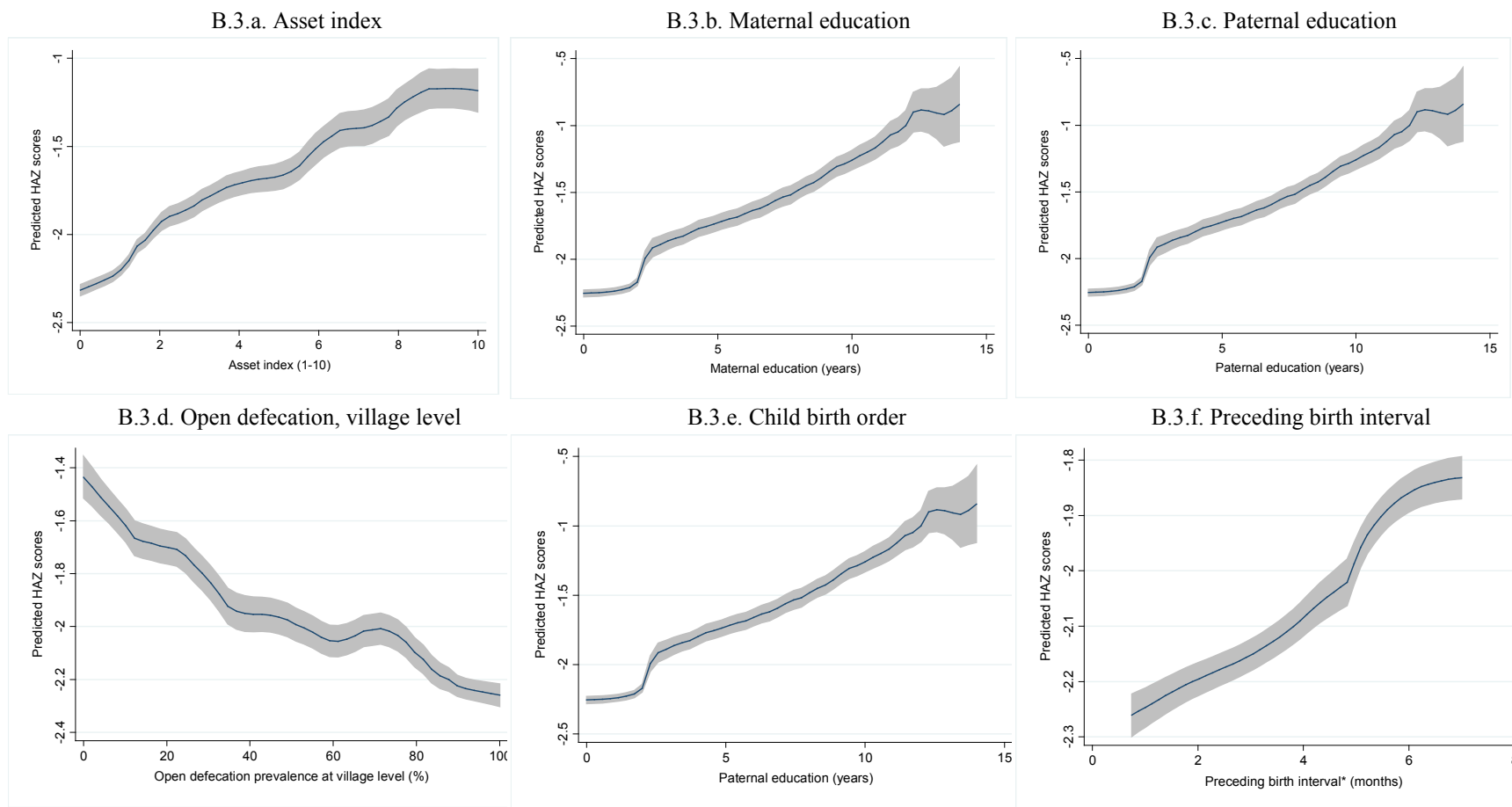
**Figure B.2 Trends in child feeding frequency, 2001 to 2011**



Source: Authors' local polynomial smoothing estimates from various rounds of the Nepal Demographic Health Survey (Nepal, MOHP, New ERA, and ORC Macro 2002; Nepal, MOHP, New ERA, and ICF International 2012).

Note: CI = confidence interval.

**Figure B.3 Nonparametric estimates of the relationship between height-for-age z scores and continuous variables**



Source: These are local polynomial smoothing predictions with 95 percent confidence intervals estimated from the 2001 (Nepal, MOHP, New ERA, and ORC Macro 2002), 2006 (Nepal, MOHP, New ERA, and ICF International 2007), and 2011 (Nepal, MOHP, New ERA, and ICF International 2012) Demographic Health Surveys.



## APPENDIX C: ADDITIONAL REGRESSION RESULTS

**Table C.1** Quantile regression estimates of child height-for-age z score (HAZ) and maternal body mass index (BMI)

Regression number	1	2	3	4
Dependent variable	HAZ	HAZ	Maternal BMI	Maternal BMI
Estimator (percentile)	Quantile	Quantile	Quantile	Quantile
Quantile value	50th = -2.1	25th = 2.95	25th = 18.65	50th = 20.10
Asset index (1–10)	0.042*** (0.008)	0.032*** (0.009)	0.118*** (0.017)	0.159*** (0.018)
Maternal education (years)	0.024*** (0.005)	0.026*** (0.006)	0.008 (0.013)	0.026* (0.014)
Paternal education (years)	0.007* (0.004)	0.013*** (0.005)	0.016 (0.010)	0.026** (0.011)
Number of antenatal care visits	0.038*** (0.009)	0.027*** (0.010)		
Iron during pregnancy	-0.074** (0.037)	-0.031 (0.042)	-0.164** (0.077)	-0.272*** (0.083)
Born in hospital (0/1)	0.188*** (0.043)	0.172*** (0.050)	0.052 (0.098)	0.275*** (0.106)
All vaccinations (0/1)	0.056 (0.038)	0.110** (0.043)		
Preceding birth interval	0.041*** (0.010)	0.022* (0.012)		
Open defecation (% of village)	-0.161*** (0.058)	-0.214*** (0.067)	-0.515*** (0.133)	-0.656*** (0.143)
Water source—tubewell (0/1)	0.095** (0.044)	0.090* (0.050)	-0.758*** (0.102)	-0.967*** (0.110)
Water source—piped (0/1)	-0.047 (0.035)	0.003 (0.040)	0.268*** (0.082)	0.273*** (0.088)
Women’s empowerment (0–1)	-0.015 (0.042)	-0.040 (0.048)	0.150 (0.094)	0.363*** (0.101)
Maternal height (centimeters)	0.059*** (0.003)	0.056*** (0.003)	-0.026*** (0.006)	-0.023*** (0.006)
<i>R</i> -squared	.19	.18	.08	9090
<i>N</i>	9,347	9,347	13,883	0.166***

Source: Authors’ estimates.

Note: Standard errors are reported in parentheses. The regressions include a number of time-invariant controls, including period fixed effects, regional and agroecological fixed effects for 13 groups, an urban dummy, district-level population density, birth order dummies, dummy variables for religion and caste, month-specific child age dummy variables (except in the maternal BMI regression), dummy variables for various categories of maternal age, and Demographic Health Survey round dummy variables. See Table 3.1 for definitions of variables. \*Significant at the 10 percent level. \*\*Significant at the 5 percent level. \*\*\*Significant at the 1 percent level.

**Table C.2 The determinants of child growth, birth size, and maternal body mass index in a pooled regression model with district fixed effects**

Regression number	1	2	3	4	5
Dependent variable	Height-for-age z score	Stunting	Severe stunting	Small size at birth	Low maternal body mass index
Estimator	OLS	LPM	LPM	LPM	LPM
Asset index (1–10)	0.046*** (0.007)	–0.015*** (0.003)	–0.008*** (0.002)	–0.002 (0.002)	–0.010*** (0.002)
Maternal education (years)	0.024*** (0.005)	–0.006*** (0.002)	–0.002* (0.001)	–0.003** (0.002)	0.001 (0.002)
Paternal education (years)	0.009** (0.004)	–0.002 (0.002)	–0.004*** (0.001)	–0.002* (0.001)	–0.004*** (0.001)
4 or more antenatal care visits	0.090** (0.036)	–0.036** (0.015)	–0.005 (0.010)	–0.035*** (0.012)	–0.015 (0.012)
Iron during pregnancy	–0.027 (0.030)	0.002 (0.012)	–0.01 (0.009)	–0.029*** (0.010)	0.024** (0.011)
Born in hospital (0/1)	0.185*** (0.040)	–0.060*** (0.015)	–0.018* (0.010)	–0.002 (0.013)	–0.01 (0.012)
All vaccinations (0/1)	0.100*** (0.038)	–0.031** (0.015)	–0.045*** (0.013)		
Preceding birth interval (years)	0.013** (0.005)	–0.004* (0.002)	–0.003* (0.002)	0.006*** (0.002)	
Open defecation (% , village)	–0.130* (0.075)	0.071*** (0.025)	0.029 (0.022)	0.031 (0.021)	0.063*** (0.021)
Water—tubewell (0/1)	0.071 (0.058)	–0.035* (0.021)	–0.024* (0.014)	–0.030* (0.018)	0.054** (0.022)
Water source—piped (0/1)	–0.008 (0.034)	0.001 (0.014)	–0.002 (0.010)	0.003 (0.012)	–0.015 (0.011)
Women’s empowerment (0–1)	0.013 (0.037)	0.003 (0.015)	0.004 (0.012)	0.007 (0.013)	–0.030** (0.012)
Maternal height (centimeters)	0.054*** (0.002)	–0.017*** (0.001)	–0.012*** (0.001)	–0.003*** (0.001)	0.004*** (0.001)
<i>R</i> -squared	.316	.217	.139	.04	.101
<i>N</i>	9,341	9,341	9,858	9,858	7,344

Source: Authors’ estimates.

Note: OLS = ordinary least squares; LPM = linear probability model. Clustered robust standard errors are reported in parentheses. The regressions include a number of omitted controls, including period fixed effects, regional and agroecological fixed effects for 13 groups, an urban dummy, district-level population density, birth order dummies, dummy variables for religion and caste, month-specific child age dummy variables (except in the maternal body mass index regression), dummy variables for various categories of maternal age, district fixed effects, and Demographic Health Survey round dummy variables. See Table 3.1 for definitions of variables. \*Significant at the 10 percent level. \*\*Significant at the 5 percent level. \*\*\*Significant at the 1 percent level.

## REFERENCES

- Acosta, A. M., and J. Fanzo. 2012. "Fighting Maternal and Child Malnutrition: Analysing the Political and Institutional Determinants of Delivering a National Multisectoral Response in Six Countries." Report prepared for DFID. Sussex, UK: Institute of Development Studies.
- Alderman, H., M. Lokshin, and S. Radyakin. 2011. "Tall Claims: Mortality Selection and the Height of Children in India." *Economics & Human Biology* 9: 393–406.
- Behrman, J. 1988. "Nutrition, Health, Birth Order and Seasonality: Intrahousehold Allocation among Children in Rural India." *Journal of Development Economics* 28: 43–62.
- Bhutta, Z. A., T. Ahmed, R. E. Black, S. Cousens, K. Dewey, E. Giugliani, B. A. Haider, B. Kirkwood, S. S. Morris, H. P. S. Sachdev, and M. Shekar. 2008. "What Works? Interventions for Maternal and Child Undernutrition and Survival." *Lancet* 371: 417–440.
- Bhutta, Z. A., J. K. Das, A. Rizvi, M. F. Gaffey, N. Walker, S. Horton, P. Webb, A. Lartey, and R. E. Black. 2013. "Evidence-based Interventions for Improvement of Maternal and Child Nutrition: What Can Be Done and at What Cost?" *Lancet* 382: 452–477.
- Black, R. E., C. G. Victora, S. P. Walker, Z. A. Bhutta, P. Christian, M. de Onis, M. Ezzati, S. Grantham-McGregor, J. Katz, R. Martorell, and R. Uauy. 2013. "Maternal and Child Undernutrition and Overweight in Low-income and Middle-income Countries." *Lancet* 382: 427–451.
- Block, S. A., W. Masters, and P. Bhagowalia. 2012. "Does Child Undernutrition Persist Despite Poverty Reduction in Developing Countries? Quantile Regression Results." *Journal of Development Studies* 48: 1699–1715.
- Burchi, F. 2012. "Whose Education Affects a Child's Nutritional Status? From Parents' to Household's Education." *Demographic Research* 27: 681–704.
- de Onis, M., C. Garza, A. W. Onyango, and E. Borghi. 2007. "Comparison of the WHO Child Growth Standards and the CDC 2000 Growth Charts." *Journal of Nutrition* 137: 144–148.
- Deaton, A., and J. Dreze. 2008. "Food and Nutrition in India: Facts and Interpretations." *Economic and Political Weekly* 44: 42–65.
- Desai, S., and S. Alva. 1998. "Maternal Education and Child Health: Is There a Strong Causal Relationship?" *Demography* 35:71–81.
- Elbers, C., and J. W. Gunning. 2013. "Evaluation of Development Programs: Randomized Controlled Trials or Regressions?" *World Bank Economic Review*. doi:10.1093/wber/lht025.
- Filmer, D., and L. Pritchett. 2001. "Estimating Wealth Effects without Expenditure Data—Or Tears: An Application to Education Enrollment in States of India." *Demography* 38: 115–132.
- GoN (Government of Nepal) and UN (United Nations). 2013. *Nepal Millennium Development Goals Progress Report 2013*. Kathmandu, Nepal: GoN and UN Country Team.
- Haddad, L., H. Alderman, S. Appleton, L. Song, and Y. Yohannes. 2003. "Reducing Child Malnutrition: How Far Does Income Growth Take Us?" *World Bank Economic Review* 17: 107–131.
- Headey, D. 2013. "Developmental Drivers of Nutritional Change: A Cross-country Analysis." *World Development* 42:76–88.
- Headey, D., A. Chiu, and S. Kadiyala. 2012. "Agriculture's Role in the Indian Enigma: Help or Hindrance to the Malnutrition Crisis?" *Food Security* 4: 87–102.
- Headey, D., J. Hoddinott, D. Ali, R. Tesfaye, and M. Dereje. 2014. *The Other Asian Enigma: Explaining the Rapid Reduction of Malnutrition in Bangladesh*. *World Development*, forthcoming.
- Heaver, R. 2002. *India's Tamil Nadu Nutrition Program: Lessons and Issues in Management and Capacity Development*. Health and Nutrition and Population Discussion Paper. Washington, DC: World Bank.

- Heaver, R., and Y. Kachondam. 2002. *Thailand's National Nutrition Program: Lessons in Management and Capacity Development*. World Bank HNP Discussion Paper. Washington, DC: World Bank.
- Horton, S. 1988. "Birth Order and Child Nutritional Status: Evidence from the Philippines." *Economic Development and Cultural Change* 36: 341–354.
- International Food Policy Research Institute. 2014. *Statistics of Public Expenditure for Economic Development (SPEED)*. Washington, DC.
- Jann, B. 2008. "The Blinder-Oaxaca Decomposition for Linear Regression Models." *Stata Journal* 8: 453–479.
- Jayachandran, S., and R. Pande. 2013. *Why Are Indian Children Shorter than African Children?* Department of Economics Working Paper. Cambridge, MA, US: Harvard University. <http://www.hks.harvard.edu/fs/rpande/papers/Indianchildrenheight.pdf>.
- Kar, K. 2003. *Subsidy or Self-respect? Participatory Total Community Sanitation in Bangladesh*. DS Working Paper 184. Brighton, UK: Institute for Development Studies.
- Khanal, M., N. Shrestha, P. D. Panta, and S. Mehata. 2013. *Impact of Male Migration on Contraceptive Use, Unmet Need and Fertility in Nepal: Further Analysis of the 2011 Nepal Demographic and Health Survey*. Calverton, MD, US: New ERA, and ICF International; Kathmandu, Nepal: Nepal, Ministry of Health and Population.
- Khanal, V., K. Sauer, R. Karkee, and Y. Zhao. 2014. "Factors Associated with Small Size at Birth in Nepal: Further Analysis of Nepal Demographic and Health Survey 2011." *BMC Pregnancy Childbirth* 14: 1471–2393.
- Khanal, V., Y. Zhao, and K. Sauer. 2014. "Role of Antenatal Care and Iron Supplementation during Pregnancy in Preventing Low Birth Weight in Nepal: Comparison of National Surveys 2006 and 2011." *Archives of Public Health* 72: 2049–3258.
- Mejía Acosta, A., and L. Haddad. 2014. "The Politics of Success in the Fight against Malnutrition in Peru." *Food Policy* 44: 26–35.
- Nepal, CBS (Central Bureau of Statistics). 2005. *Poverty Trends in Nepal: 1995–96 and 2003–04*. Kathmandu, Nepal: National Planning Commission Secretariat.
- Nepal, CBS and United Nations. 2013. *Nepal Millennium Development Goals Progress Report 2013*. Kathmandu, Nepal: National Planning Commission and United Nations Country Team of Nepal.
- Nepal, CBS and World Bank. 2006. *Resilience amidst Conflict: An Assessment of Poverty in Nepal, 1995–96 and 2003–04*. Report No. 34834-NP. Kathmandu, Nepal: National Planning Commission Secretariat and World Bank.
- Nepal, Ministry of Urban Development. 2013. "Nepal Country Paper on Sanitation." Background paper for the South Asian Conference on Sanitation "Sanitation for All: All for Sanitation," Kathmandu, Nepal, October 22–24.
- Nepal, MOHP (Ministry of Health and Population), New ERA, and ICF International. 2007. *Nepal Demographic and Health Survey 2006*. Kathmandu, Nepal; Calverton, MD, US.
- . 2012. *Nepal Demographic and Health Survey 2011*. Kathmandu, Nepal; Calverton, MD, US.
- Nepal, MOHP, New ERA, and ORC Macro. 1997. *Nepal Demographic and Health Survey 1996*. Kathmandu, Nepal; Calverton, MD, US.
- . 2002. *Nepal Demographic and Health Survey 2001*. Kathmandu, Nepal, and Calverton, MD, US.
- Nubé, M. 2007. *The Asian Enigma: Predisposition for Low Adult Body Mass Index among People from South Asian Descent*. Staff Working Paper WP-07-01. Amsterdam: Centre for World Food Studies.
- Pande, R. 2003. "Selective Gender Differences in Childhood Nutrition and Immunization in Rural India: The Role of Siblings." *Demography* 40: 395–418.
- Ramalingaswami, V., U. Jonson, and J. Rohde. 1997. "The Asian Enigma." In *The Progress of Nations*, edited by P. Adamson. New York: UNICEF.

- Royston, P., Altman, D. G., and W. Sauerbrei. 2006. "Dichotomizing Continuous Predictors in Multiple Regression: A Bad Idea." *Statistics in Medicine* 25: 127–141.
- Rutstein, S. O. 2005. "Effects of Preceding Birth Intervals on Neonatal, Infant and Under-five Years Mortality and Nutritional Status in Developing Countries: Evidence from the Demographic and Health Surveys." *International Journal of Gynecology & Obstetrics* 89: 26.
- Shrimpton, R., C. G. Victora, M. de Onis, R. Costa Lima, M. Blössner, and G. Clugston. 2001. "The Worldwide Timing of Growth Faltering: Implications for Nutritional Interventions." *Pediatrics* 107:e75.
- Smith, L. C., and L. Haddad. 2000. *Explaining Child Malnutrition in Developing Countries: A Cross-country Analysis*. Washington, DC: International Food Policy Research Institute.
- Spears, D. 2013. *How Much International Variation in Child Height Can Sanitation Explain?* Working paper. Princeton, NJ, US: Princeton University.
- Spears, D., A. Ghosh, and O. Cumming. 2013. "Open Defecation and Childhood Stunting in India: An Ecological Analysis of New Data from 112 Districts." *PLoS ONE* 8:e73784.
- Srinivasan, C. S., G. Zanello, and B. Shankar. 2013. "Rural-urban Disparities in Child Nutrition in Bangladesh and Nepal." *BMC Public Health* 13: 1471–2458.
- Thomas, D., J. Strauss, and M. H. Henriques. 1991. "How Does Mother's Education Affect Child Height?" *Journal of Human Resources* 26: 183–211.
- UNICEF. 1990. *Strategy for Improved Nutrition of Children and Women in Developing Countries*. UNICEF Policy Review 1990-1 (E/ICEF/1990/L.6). New York.
- United Nations. 2014. National Accounts Main Aggregates Database. Accessed February 22. <http://unstats.un.org/unsd/snaama/selbasicFast.asp>.
- Weinberg, C. R. 1995. "How Bad is Categorization?" *Epidemiology* 6: 345–347.
- WHO (World Health Organization). 2006. "Reliability of Anthropometric Measurements in the WHO Multicentre Growth Reference Study." *Acta Paediatrica* 450: 38-46.
- . 2014. Global Database on Child Growth and Malnutrition. Accessed February 22. <http://www.who.int/nutgrowthdb/database/en/>.
- World Bank. 2006. *Repositioning Nutrition as Central to Development: A Strategy for Large-scale Action*. Washington, DC.
- . 2010. *Nepal Public Expenditure Review*. Report No. 55388-NP. Kathmandu, Nepal: Poverty Reduction and Economic Management Sector Unit, South Asia Region, World Bank.
- . 2014. World Development Indicators Online. Accessed February 2. <http://data.worldbank.org/data-catalog/world-development-indicators>.



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