Mother's Education and Children's Nutritional Status: New Evidence from Cambodia

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This study uses data from Cambodia's 2005 Demographic and Health Survey to examine how three measures of children's nutritional status vary by mother's educational attainment. To identify mechanisms for that association, the study analyzes birth size, which depends on factors during gestation, and low height-for-age (stunting) and low weight-for-height (wasting), which are affected by factors that operate after birth. In multivariate specifications that control for socioeconomic status, mother's education is strongly inversely associated with stunting, but not small birth size or wasting. Addition of household composition and environmental factors to the model reduces the association between mother's education and child nutritional outcomes only slightly.

I. INTRODUCTION

Improving girls' access to schooling and closing the gender gap in education has received an enormous amount of attention in academic and policy dialogues. Higher educational attainment yields a host of benefits for girls and women in terms of their autonomy, rights, labor market outcomes, and social status. These improvements occur due to acquisition of greater human capital in the form of knowledge and skills that contribute to greater labor market productivity and greater empowerment of women. Educating girls also has a functional importance in terms of benefits for the next generation, as the socioeconomic status, actions, and choices of more-educated mothers during pregnancy and child rearing can have a large impact on children's nutritional status, well-being, and survival (Frongillo et al. 1997, Pelletier 1998, Webb and Block 2004).

The benefits of mother's education for children's health outcomes and nutritional status commonly accrue through higher socioeconomic status, which in turn operates through a set of "proximate determinants" of health that directly influence child health outcomes and nutritional status (Mosley

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and Chen 1984). The proximate determinants include fertility factors, environmental hazards, feeding practices, injury, and utilization of health services. Numerous empirical studies have linked mother's education with such proximate determinants (e.g., Behrman and Wolfe 1987, Sandiford et al. 1995, Guilkey and Riphahn 1998). The literature review below discusses relations among these variables.

A related issue in the development literature revolves around strong cultural preferences for sons, which is reflected in discrimination against girls in decisions about health care, schooling, and feeding. Sen (1989) drew attention to this "missing women" problem with evidence of unusually high male to female population ratios in Asia and North Africa. The preference for sons and this shortfall of women relative to men in the population can arise from a number of cultural, economic, and institutional factors that cause parents to treat boys in ways that favor their growth and development over girls (Goodkind 1996, Bhargava 2006). The absence of social protection institutions for old age, relatively fewer employment opportunities for women, and strict family planning policies can reinforce the lower social value of women and the cultural preference for having sons (Berik 2008).

Several recent studies provide information about gender preference in Cambodia. A study by Fuse (2008) of attitudes related to gender preferences for children using data from 40 Demographic and Health Surveys found that 53 percent of Cambodian respondents indicated a preference for gender balance among their offspring. Those who reported a gender preference were nearly twice as likely to express a daughter preference as a son preference (27 percent versus 15 percent). Higher mother's education and greater household wealth were associated with slightly greater preference for girls, but that finding occurred only among people who had no living children, and was no longer statistically significant in a multivariate model controlling for other socioeconomic and demographic factors. In contrast, Filmer et al. (2008) documented particularly strong son preference in South and Central Asia, with a smaller but still statistically significant degree of son preference in East Asia, including Cambodia, as reflected by a greater probability of continued childbearing among families that have only daughters compared to those with at least one son.

Our study contributes to this body of research with new evidence from Cambodia on how children's nutritional status varies by mother's educational attainment. Three measures of poor nutritional status in young children are used: small birth size, stunting (low height-for-age), and wasting (low weight-for-height). Each of these measures captures a different aspect of child growth and development. Birth size is affected by endogenous factors that operate

during the period of gestation, including genetic influences, mother's antenatal nutrition, and health. Stunting and wasting are affected by exogenous factors that operate after a child is born, including environmental exposure, the child's nutritional intake, illnesses, and other external factors that are influenced by both socioeconomic factors and the physical environment (Puffer and Serrano 1973). By contrasting the three different nutritional outcomes, we can differentiate between patterns that result from influences that take place before the mother knows the sex of her child, and patterns that result from behaviors after she has that knowledge.

Furthermore, the paper explores gender differences in children's nutritional status and how any such gender differences vary by mother's educational attainment. A priori, we expect that consistent with international patterns, boys will be slightly less likely than girls to be small at birth, but this expected gender difference will not be exacerbated by differential behavior of mothers expecting boys versus those expecting girls. As one of Asia's poorest countries, Cambodia lacks widespread access to advanced technology in reproductive health. As of 2005, just a small share of Cambodia's 1,158 public health facilities had the appropriate reproductive health equipment and trained professionals to offer abortion services (Sherman and Fetters 2007). Hence it is extremely rare for mothers to be able to ascertain the sex of a fetus before it is born. As a consequence, mothers cannot differentiate their antenatal behavior to reflect a sex preference, so male and female fetuses are expected to have essentially identical antenatal experiences in terms of their mother's nutritional intake, use of health services, and other factors that determine fetal growth. Once a child is born, however, the mother knows the child's sex (and now gender) and may treat boys and girls differently in terms of the broad array of factors that affect child growth. Note the use of the term "sex" rather than "gender" of a fetus: at that phase of development, the distinction is purely biological—without the social, political, or behavioral overlay that encompasses gender.

This analysis utilizes data from the Cambodia Demographic and Health Survey for 2005, a large nationally-representative sample of women between the ages of 15 and 49 and the members of their households. The data are used to test three hypotheses. First, the prevalence of each of the indicators of poor nutritional status—small birth size, stunting, and wasting—is expected to decrease with increasing mother's education. Second, there will be small, if any, gender differences in the prevalence of small birth size, but girls will have higher rates than boys of both stunting and wasting. Third, the disadvantage for girls in stunting and wasting is expected to decrease with increasing mother's education. This study builds on Hong and Mishra (2006)

in several ways: the use of a more recent round of the Cambodia Demographic and Health Survey; the analysis of three different measures of children's nutritional status representing different timing and duration of factors causing suboptimal growth; and the explicit focus on how son preference might vary by mother's education.

II. CONCEPTUAL FRAMEWORK LINKING MOTHER'S EDUCATION AND CHILDREN'S WELL-BEING

Studies using household-level data have found mother's education to be positively associated with a number of measures of infant and child health and nutritional status (see, for example, Wolfe and Behrman 1982, Thomas et al. 1991, Bicego and Boerma 1993, Hobcraft 1993, Miller and Korenman 1994, Desai and Alva 1998, Waters et al. 2004, Boyle et al. 2006). Results pointing to the importance of socioeconomic status indicators such as mother's education to children's nutritional status are consistent with findings in Yip et al. (1992) that poor growth status among Asian children—as measured by low birth weight, low height-for-age, and low weight-for-height—is mostly associated with nutritional and health determinants rather than genetic factors. At the macroeconomic level, higher female literacy rates are a positive predictor of lower infant and child mortality, with the implication that educating women and girls in low-income countries is associated with reduced child mortality (Bhargava 2006).

This large body of empirical work has made clear that mother's education captures several distinct but often related attributes. Theoretical work also suggests a complex set of channels through which mother's education affects children's nutritional status—including preferences, decisions about health inputs, and income effects (Schultz 1984). Empirical work has also shown that education can serve as a means of adopting new health beliefs, gaining general knowledge, and applying specific knowledge about health and nutritional practices that promote child health (Glewwe 1999). Furthermore, women's education can also affect child health because more education is linked with higher household income, which in turn strengthens families' abilities to handle adverse economic or environmental shocks, finance health care needs, and afford more nutritious food. In a country such as Cambodia, where median educational attainment for adult women is less than 3 years of schooling and only 16 percent have secondary or higher education (NIPH/NIS/ORC 2006, Table 2.4), those with higher education tend to be a fairly select group from wealthier families of origin.

Hence families with more-educated mothers are likely to have more income and assets than those with less-educated mothers, giving them access to more and better food, shelter, and protection from environmental hazards. Socioeconomic determinants thus affect child health and nutritional status through a set of intermediary mechanisms that encompass household composition, dietary intake, medical treatment, and environmental contaminants. The remainder of this section uses the socioeconomic and proximate determinants framework to consider the literature about how mother's education affects child well-being.

A. Socioeconomic Determinants of Child Health

At the household level, income and wealth are linked to child well-being through the effects that purchased goods and services have on the proximate determinants of child health. Greater household income and assets directly raise the ability to purchase sufficient quantities of nutritious foods, clean water, clothing, adequately-ventilated housing, fuel for proper cooking, safe storage of food, personal hygiene items, and health services (see, for example, Boyle et al. 2006, Hong et al. 2006). In Cambodia, more-educated mothers do, on average, live in wealthier households. Among households in the lowest wealth quintile, only 5 percent of mothers had at least some secondary schooling, compared to 52 percent of mothers in the wealthiest quintile (NIPH/NIS/ORC 2006, Table 4.2.1). Fujii and Ear (2002) showed that in Cambodia, mother's total years of education more strongly predict total household expenditures than do head of household's total years of education. The results imply that educated mothers are able to contribute to household income, which allows for greater household expenditures.

At the individual level, greater education for mothers contributes to new skills, beliefs, and choices about sound health and nutritional practices that directly influence the proximate determinants of child health. For instance, knowledge obtained during a mother's education can affect choices about antenatal care and about children's nutrition, hygiene, and health care. To the extent that more-educated mothers make healthier choices for themselves during pregnancy, education will have a direct effect on the health of the child at birth. For example, in Cambodia, women with secondary schooling and above were twice as likely to receive antenatal care and 70 percent more likely to take iron pills while pregnant as those with no education (NIPH/NIS/ORC 2006, Tables 13.1 and 13.3). The proportion of Cambodian children who have all their basic vaccinations is 60 percent higher among

children of mothers with secondary schooling and above than among those of mothers with no education (NIPH/NIS/ORC 2006, Table 14.3).

Also at the individual level, father's education is an important determinant of household wealth and income. Unlike the effects of mother's education on child health, which operate through decisions about the proximate determinants as noted above, father's education is believed to affect child health indirectly and more distally, through its effect on household income (Mosley and Chen 1984). There could also be spillover effects from the educational attainments of multiple household members that could have additional benefits for children's nutritional status (Lindelow 2008). In Cambodia, husbands typically have higher educational attainment than their wives, but the gap in years of education between spouses decreases as the wife's education increases: the husband-wife gap in schooling averages 3 years for women with no education, compared to 0.2 years for women with secondary schooling and above (NIPH/NIS/ORC 2006, Table 20.2).

Improved socioeconomic status also involves changes in norms and attitudes that influence the economic decisions and nutrition-related behaviors of mothers and fathers. Stronger bargaining power for women within the household can facilitate decision-making that improves child health outcomes. Central to the social context in which mothers and fathers operate is bargaining power, and an important change that comes with more education for women in developing countries is increased empowerment and autonomy. For example, in the 2005 Cambodia Demographic and Health Survey, 34 percent of women with no education felt that they had the final say in making decisions about money, contraception, and children's education and health care, compared to 49 percent for women with secondary schooling and above (NIPH/NIS/ORC 2006, Table 20.5). Finally, greater autonomy for women can also promote greater utilization of antenatal care and vaccination programs.

B. Demographic Determinants of Child Health

Household composition measures, including the number of children in a household, whether the household is headed by a woman, and the mother's age at first birth, are also associated with both mother's educational attainment and children's nutritional outcomes. Consistent with patterns in other developing countries, less-educated mothers in Cambodia have more children on average and are younger at the time they first give birth (NIPH/NIS/ORC 2006, Tables 5.2 and 5.7). Less-educated mothers in Cambodia also have a greater likelihood of living in single-parent households.

In other developing countries such as Jamaica, Indonesia, and Philippines, the number of children in a household, number of parents in a household, and female headship are each associated with birth outcomes, child survival rates, and nutritional status (e.g., Bronte-Tinkew and DeJong 2004, Heaton et al. 2005). In particular, more children in a household are associated with more competition for scarce resources, which could reduce children's dietary intake, decrease access to medical treatment, and increase their exposure to infectious diseases. A greater number of adults in the household can also bring about more unsanitary living conditions and a heightened risk for the spread of disease (Heaton et al. 2005). Female household heads have on average fewer financial resources and greater demands on their time, and have been linked with worse nutritional status outcomes for children (e.g., Bronte-Tinkew and DeJong 2004).

C. Proximate Determinants of Child Health

Proximate determinants of health consist of the biological mechanisms that directly affect the health, growth, and development of children. These include dietary intake, illness burden, and exposure to environmental contaminants or hazards. Environmental hazards encompass risks associated with the transmission of infectious agents or exposure to noxious materials such as ambient smoke. Transmission of infectious agents, which can in turn have a direct influence on children's nutritional status, occurs through a number of routes, including the air, particularly with the spread of respiratory diseases; dirty food, water, and hands, which can cause diarrhea and other intestinal illnesses; skin and soil, the conduits of skin infections; and insects, which can spread viral and parasitic diseases (Scrimshaw et al. 1968, Mosley and Chen 1984). Greater education for mothers operates through this mechanism because households of higher socioeconomic status are more likely to have improved facilities that prevent or limit the transmission of infectious agents through these routes (Pongou et al. 2006). In Cambodia, households in which mothers had secondary or higher education were more than 8 times as likely as those with no education to dispose of their children's stool in a latrine or toilet (NIPH/NIS/ORC 2006, Table 14.10). Rates of diarrheal disease showed a similar inverse relation with mother's education: 16 percent of children of mothers with secondary or higher education had diarrhea in the two weeks preceding the survey, compared to 21 percent of those whose mothers had no education (NIPH/NIS/ORC 2006, Table 14.6).

III. DATA AND METHODOLOGY

Construction of the sample started with the Children's Recode of the 2005 Cambodia Demographic and Health Survey (NIPH/NIS/ORC 2006), which contains observations for 8,290 children ages 0 to 59 months. By design, height and weight measurements were recorded for roughly half of these children. Information on treatment of drinking water and age of household members was merged in from the Household Member Recode. After dropping observations with missing values for any of the variables, an analytic sample size of 3,542 children remained. A robustness check on the representativeness of the analytic sample relative to the overall sample of children under age 5 revealed that the distributions of most variables were very close (usually within 1 percentage point for each of the categories and within a couple of units for the continuous variables). Hence differential selection into the analytic subsample did not appear to be a problem, which would be expected because inclusion of children in the height and weight modules was by design rather than due to differential non-response of survey participants.

In order to test the various hypothesized mechanisms that could link mother's education to children's nutritional status outcomes, we estimated a series of nested models starting with a baseline model of child outcomes regressed on the mother's education and the sex of the child, then introducing *socioeconomic factors*, *household composition*, and *environmental exposure* variables.[1] This format allowed us to test alternative mechanisms for how mother's education relates to nutritional status, in isolation and in a full model that included all of the explanatory variables.

This series of models was estimated for each of the three dependent variables: small size at birth, stunted, and wasted. All statistical analyses were weighted to the national population of women aged 15–49 in Cambodia using the sampling weights provided in the 2005 Demographic and Health Survey (NIPH/NIS/ORC 2006, Appendix A). Because the survey records multiple children per household as separate observations, the standard errors for clustering at the level of the household were corrected using Stata's cluster-analysis management tool (StataCorp 2005).

[1]We also estimated a separate model that included measures of women's empowerment to make decisions in the household. However, because of the way the study was designed there were only 632 women for whom data about both decision-making and children's height and weight were collected. None of the women's empowerment variables had statistically significant coefficients in the full models (not shown).

A. Dependent Variables

1. Birth Weight

The Cambodia Demographic and Health Survey collected both a subjective and an objective measure of birth weight. For the subjective measure, mothers were asked to assess whether their child was "very small," "smaller than average," "average," "larger than average," or "very large;" the questionnaire does not define what is meant by those terms (NIPH/NIS/ORC 2006). For this analysis, children who were classified "very small" or "smaller than average" were coded as "small at birth." The objective measure of birth weight was asked in grams. Following the World Health Organization definition (WHO 1950), low birth weight is defined as a birth weight of less than or equal to 2,500 grams (about 5.5 pounds), based on the objective birth weight. In order to minimize retrospective recall bias, the birth weight measures were collected only for children aged 5 completed years (60 months) at the time of the survey.

Objective birth weight was available for only 40 percent of children under age 5 in the 2005 Cambodia sample. Moreover, non-response to objective birth weight decreased markedly with increasing mother's education, due to the greater likelihood that children of higher socioeconomic status (SES) were weighed at birth. Only 23 percent of mothers with no education who provided the subjective assessment of size at birth also reported a birth weight, compared to 38 percent of those with primary education and 70 percent of those with secondary education or higher (NIPH/NIS/ORC 2006, Table 14.1).[2] Subjective size at birth correlated well with objective birth weight both in the Cambodia data and in Blanc and Wardlaw's (2005) study of 62 Demographic and Health Surveys, so the subjective measure was used in order to conduct the analysis on a representative sample rather than one biased by greater omission of rural and low SES women.

[2]This pattern is consistent with that observed in an international comparative evaluation of low birth weight indicators in the Demographic and Health Survey by Blanc and Wardlaw (2005), which found that infants who were weighed at birth were more likely to be born to more-educated women, those in urban areas, and in medical facilities or attended by trained medical personnel. They also concluded that because such infants are less likely than others to have low birth weight, the prevalence of low birth weight was underestimated if the sample was restricted to those for whom objective birth weight was available.

2. Stunting and Wasting

Stunting and wasting are anthropometric indicators of nutritional status based on height, weight, age, and gender (WHO 1995). Stunting compares a child's height (in centimeters) against an international standard distribution of height for children of the same gender and age (in months). Children's weights and heights were collected as part of the Household Survey, using standardized equipment and protocols established by the Demographic and Health Surveys. Although there is some evidence of heaping in the recorded heights and weights, evaluations have concluded that there is no systematic bias in the measurement of these variables (Pullum 2008).

Children whose height-for-age is more than two standard deviations below the median of the NCHS/CDC/WHO International Reference Population for children of the same gender are classified as stunted (NIPH/NIS/ORC 2006). Thus, if the z-score for height-for-age is below –2.0, the child is categorized as stunted. Children whose weight-for-height is more than two standard deviations below the median of the NCHS/CDC/WHO International Reference Population for children of the same gender are classified as wasted. Thus, if the z-score for weight-for-height is below –2.0, the child is categorized as wasted. Stunting is an indicator of long-term nutritional status, capturing the effects of chronic nutritional deprivation or chronic or recurrent illness. Wasting, in contrast, captures short-term nutritional status, including recent, short-term inadequate nutritional intake, or recent illnesses such as diarrhea that cause weight loss. Low weight-for-age (underweight) is not analyzed because it does not distinguish as effectively between effects of long-term and short-term deprivation as do analyses of stunting and wasting, respectively.

The international reference population for these comparisons was defined by the United States National Center for Health Statistics and accepted by the United States Centers for Disease Control and Prevention (NIPH/NIS/ORC 2006). Use of this international standard was derived from the fact that well-nourished children in all population groups follow very similar trajectories in growth (height and weight) as they age, and therefore exhibit essentially the same distributions of weight and height at given ages (Martorell and Habicht 1986).

B. Independent Variables

The "Baseline" model includes a set of dummy variables for mother's educational attainment (primary school, and secondary school and above, with

no schooling as the reference category). It also includes a dummy variable for whether the child is a boy, and for age of the child in years at the time of the survey (for the models of stunting and wasting). The "SES-only" model adds to the baseline a set of dummy variables that capture different dimensions of socioeconomic status: the quintile ranking for a household wealth index, how the mother is paid at work, mother's and father's occupation in agriculture, and father's level of educational attainment. Classifications and reference categories for each of these variables are shown in Table 1.

Table 1. **Children's Nutritional Status and Household Factors, 2005 Cambodia DHS**

	Unweighted N	Percent of Sample, Weighted
Overall sample	3,542	100.0
Children's nutritional status		
Small size at birth		
Yes	508	13.7
No	3,034	86.3
Low birth weight (<=2,500 grams)†		
Yes	204	15.5
No	1,068	84.5
Stunted		
Yes	1,382	36.8
No	2,160	63.2
Wasted		
Yes	256	7.5
No	3,286	92.5
Mother's education		
No schooling	1,023	23.8
Primary school	1,986	58.6
Secondary or higher	533	17.6
Sex of child		
Boy	1,757	48.5
Girl	1,785	51.5
Age of child, yrs.		
<1	671	18.7
1	753	21.8
2	686	19.2
3	731	21.0
4	701	19.3
Proxies for socioeconomic status		
Wealth index		
1st (poorest) quintile	966	25.0
2nd quintile	828	22.4
3rd quintile	685	18.9
4th quintile	537	16.6
5th (richest) quintile	526	17.1
Type of mother's earnings		
Unpaid	780	21.8
Cash only	1,100	35.4
Cash and in-kind	502	9.2
In-kind only	1,160	33.7

Continued

Table 1—*Continued*

	Unweighted N	Percent of Sample, Weighted
Mother's occupation in agriculture		
Yes	2,002	53.7
No	1,540	46.3
Father's occupation in agriculture		
Yes	2,276	60.9
No	1,266	39.1
Father's educational attainment		
No schooling	717	16.4
Primary school	1,752	49.1
Secondary or higher	1,073	34.5
Household composition		
Number of children under 18 yrs of age		
1–2	1,322	41.8
3	837	23.2
4+	1,383	35.1
Number of adults		
1	110	3.2
2–3	2,654	75.8
4+	778	21.0
Female-headed household		
Yes	243	7.3
No	3,299	92.7
Mother's age at first birth (years)		
15–19	1,333	36.1
20–24	1,715	48.5
25+	494	15.3
Household environmental factors		
Mother smokes cigarettes		
Yes	337	5.4
No	3,205	94.6
Has improved toilet facility		
Yes	651	20.2
No	2,891	79.8
Has clean drinking water		
Yes	2,089	58.7
No	1,453	41.3
Geographic region		
Phnom Penh	149	7.9
Other urban	655	9.6
Other rural	2,738	82.5

† refers to a smaller sub-sample of 1,272 children for whom objective birth weight was recorded.

DHS = Demographic and Health Survey.

Notes: Stunted is defined as height-for-age more than two standard deviations below the reference median for children of the same gender (z-score below –2.0). Wasted is defined as weight-for-height more than two standard deviations below the reference median for children of the same gender. Weighted to national level with weights provided by the 2005 Cambodia DHS.

Source: Authors' calculations based on NIPH/NIS/ORC (2006).

The next two models add to the SES-only model two alternative sets of intermediate determinants that link mother's education to children's health outcomes. The "SES & HH comp" model adds household composition variables including dummy variables for presence of four or more adults in

the household, whether or not a woman is the household head, and mother's age at first birth. Continuous measures of the number of children in the household were included for each of three age groups (under 5, 5–12, and 13–17 years) to capture the age composition of siblings. Religion would also be a relevant household characteristic but 92 percent of mother-child pairs are Buddhist, so there was not enough variation to include religion in a multivariate specification.

Next, the "SES & environ" model adds environmental factors to the SES-only model. These factors include dummy variables for whether the mother smokes, whether the household has an improved toilet, and whether the household's water is treated before it is used for drinking or cooking. To take into account effects of factors such as rainfall, temperature, and other climatic factors that influence child growth through seasonal variation in nutritional intake and incidence of disease, dummy variables were included for the month in which the weight and height measurements were taken, following the guidance in Pullum (2008). Geographic region contrasts the capital city region of Phnom Penh (which includes both urban and rural areas) against other urban areas and other rural areas. The "Full" model incorporates all of the SES, household composition, and environmental factors. Tolerance statistics revealed that multicollinearity among the full set of independent variables was not a concern (Wooldridge 2002, Academic Technology Services 2009).

Table 1 reports the distribution of the sample in terms of children's nutritional status, mother's education, sex and age of the child, socioeconomic status, household composition, and environmental conditions. Of the three indicators of nutritional status, a considerably higher percentage of children are classified as stunted (37 percent; low height-for-age) compared to small at birth (14 percent) and wasted (8 percent; low weight-for-height). Note that the 14 percent of children who are subjectively assessed by their mothers to be small at birth is very close to the 16 percent figure for objective low birth weight (<=2,500 grams) that is based on the smaller sub-sample for children with recorded measurements for objective birth weight.[3]

In terms of educational attainment, just 18 percent of children have mothers with a secondary school education or higher, compared to 59 percent with primary school and 24 percent with no education. The sample is split fairly evenly by sex of the child. Among the socioeconomic characteristics, of

[3]There is considerable heaping of cases with birth weight equal to 2,500 grams. If low birth weight is defined as strictly less than 2,500 grams, then only 9 percent of children are considered low birth weight. Blanc and Wardlaw's (2005) international comparison of Demographic and Health Survey data found this pattern across many countries, and they concluded that using the standard WHO definition with these data understates the actual prevalence of low birth weight.

the children whose mothers are paid, about equal numbers receive cash versus in-kind earnings. Fifty-four percent of the children's mothers and more than 60 percent of their fathers work in agricultural jobs. Compared to the mother's education distribution, the father's distribution is skewed away from no schooling (16 percent) toward secondary schooling and above (35 percent).

Among the measures for household composition, about 42 percent of children come from households with one or two children under the age of 18 living at home, while another 35 percent are in households with four or more children. Only a small percentage of children in the sample (7 percent) live in female-headed households, and over three quarters are in households with two to three adults. Among the household environmental factors, just 20 percent of children are in households with access to an improved toilet facility, but nearly 60 percent are in households that treat their water before drinking and cooking. Only about 5 percent of children in the sample have mothers who smoke cigarettes.

IV. EMPIRICAL ANALYSIS

A. Bivariate Associations with Mother's Education

We cross-tabulated each of the measures of nutritional status and independent variables by mother's education in order to test whether there was a statistically significant bivariate association among those variables prior to entering them into the multivariate specifications. The design-based F statistic is reported as a test of independence (NIPH/NIS/ORC 2006, Rao and Scott 1984).

B. Children's Nutritional Status by Mother's Education

Table 2 reports bivariate statistics on the prevalence of small birth size, low birth weight, stunting, and wasting among children of mothers with varying levels of education. Small size at birth, low birth weight, and stunting all show the expected inverse relationship with mother's education. Children of mothers with at least secondary schooling are roughly half as likely to be small at birth (9.5 percent) as those born to mothers with no schooling (18 percent) ($p<0.01$). Likewise, low height-for-age (stunting) is only about half as common among children of mothers with secondary schooling or more as among children of mothers with no schooling (22 percent and 46 percent, respectively; $p<0.01$). Wasting (low weight-for-height), however, shows very little variation by mother's education.

Table 2. **Children's Nutritional Status and Household Factors by Mother's Educational Attainment, 2005 Cambodia DHS**

	Mother's Education (% of group)			Design-based F Statistic
	None (N=1,023)	Primary (N=1,986)	Secondary+ (N=533)	
Children's nutritional status				
Small size at birth	18.1	13.2	9.5	6.7*
Low birth weight	18.4	16.3	12.7	1.1
Stunted	45.6	37.7	21.7	28.6*
Wasted	7.8	6.9	8.8	0.9
Male child	50.3	47.8	48.4	0.5
Proxies for socioeconomic status				
Wealth index				
1st (poorest) quintile	43.0	23.8	4.9	
2nd quintile	27.0	24.5	9.3	
3rd quintile	14.8	22.3	13.0	44.6*
4th quintile	9.7	16.5	26.2	
5th (richest) quintile	5.6	12.9	46.6	
Type of mother's earnings				
Unpaid	19.4	23.1	20.7	
Cash only	28.8	32.1	55.2	13.8*
Cash and in-kind	13.5	9.0	4.1	
In-kind only	38.3	35.9	20.1	
Mother's occupation in agriculture	65.8	56.1	29.5	48.7*
Father's occupation in agriculture	70.4	64.7	35.2	49.8*
Father's education				
No schooling	38.0	11.5	3.4	
Primary school	46.3	58.5	21.5	98.2*
Secondary or higher	15.7	29.9	75.1	
Household composition				
Number of children under 18 yrs of age				
1–2	36.1	42.1	48.4	
3	23.5	23.7	20.9	3.0†
4+	40.4	34.2	30.6	
Number of adults				
1	3.8	3.6	1.1	
2–3	81.3	75.7	69.0	7.1*
4+	15.0	20.7	29.9	
Female-headed household	9.0	7.5	4.4	3.1†
Mother's age at first birth (years)				
15–19	37.2	39.0	25.0	
20–24	47.5	48.0	51.8	7.3*
25+	15.3	13.0	23.2	
Household environmental factors				
Mother smokes cigarettes	9.9	5.2	0.3	23.4*
Has improved toilet facility	8.0	15.4	52.7	127.7*
Has clean drinking water	43.5	57.8	82.5	53.4*
Geographic region				
Phnom Penh	5.5	6.0	17.6	

Continued

Table 2—*Continued*

	Mother's Education (% of group)			Design-based F Statistic
	None (N=1,023)	Primary (N=1,986)	Secondary+ (N=533)	
Other urban	9.1	8.9	12.4	13.0*
Other rural	85.4	85.1	70.0	

* means p<0.01, † means p<0.05.

DHS = Demographic and Health Survey.

Notes: Stunted is defined as height-for-age more than two standard deviations below the reference median for children of the same gender (z-score below –2.0). Wasted is defined as weight-for-height more than two standard deviations below the reference median for children of the same gender. Weighted to national level with weights provided by the 2005 Cambodia DHS. The Pearson chi-squared test statistic for independence is corrected for clustering at the household level and is converted into a design-based F statistic.

Source: Authors' calculations based on NIPH/NIS/ORC (2006).

C. Socioeconomic Status by Mother's Education

The remainder of Table 2 presents results of statistical tests that show how each of the explanatory variables varies by mother's education. The results for gender of the child indicate a lack of sex selection, with male children composing close to 50 percent of each of the mother's education groups (design-based F statistic=0.5; not significant). Each of the socioeconomic status variables exhibits a large, statistically significant inverse association with mother's educational attainment. For example, 43 percent of children born to mothers with no education are in the lowest wealth index quintile, compared to just 5 percent of those whose mothers have secondary education ($p<0.01$). At the other extreme, 47 percent of children with the most-educated mothers are in the highest wealth index quintile, compared to just 6 percent of those whose mothers have no education. These marked differences between children of more- and less-educated mothers are also observed in the frequency with which their mothers and fathers have agricultural jobs. More-educated mothers are nearly twice as likely to earn cash only, and just half as likely to receive in-kind earnings as their less-educated counterparts ($p<0.01$).

Not surprisingly, mother's and father's educational attainment are strongly positively correlated. Compared with households in which the mother has no schooling, those in which mothers have at least a secondary education are only one-tenth as likely to have a father with no schooling (38 percent versus 3 percent) and five times as likely to have a father with secondary or higher education (16 percent versus 75 percent; $p<0.01$).

D. Environmental Factors by Mother's Educational Attainment

Each of the household environmental factors is strongly and statistically significantly associated with mother's education in ways that would be expected to reduce health risks among the more highly educated. Less than one percent of children with mothers in the highest education group are in households in which the mother smokes cigarettes, compared with 10 percent of children whose mothers have no education ($p<0.01$). Improved toilet facilities are 6.5 times as common in the most-educated group compared to the least-educated group (53 percent versus 8 percent; $p<0.01$), while having clean water was about twice as likely. Children with more-educated mothers are more than three times as likely to live in the Phnom Penh capital region, and one-third more likely to live in other urban areas as children with mothers in the two less-educated groups ($p<0.01$), with correspondingly fewer cases in rural areas.

E. Children's Nutritional Status by Gender

Bivariate analysis reveals very small, substantively trivial gender differences in each of the three indicators of poor nutritional status, none of which reach conventional levels of statistical significance. Consistent with international patterns that girls weigh less than boys at birth, 15 percent of girls and 13 percent of boys are small at birth ($F=1.70$; $p=0.19$). The slight gender difference is reversed for stunting, with 35 percent of girls classified as stunted compared to 38 percent of boys ($F=2.02$; $p=0.16$). The incidence of wasting is virtually the same for girls and boys, at about 7.4 percent ($F=0.001$; $p=0.97$).

F. Multivariate Analysis of Children's Nutritional Status

Results from the multivariate estimations of the series of five logit models are reported in Table 3 for small size at birth, Table 4 for stunting, and Table 5 for wasting. In the case of small size at birth, the Baseline model shows a statistically significantly lower risk of small size at birth as mother's education increases, with odds ratios (ORs) of 0.68 and 0.47 for primary and secondary education, respectively, when each is compared to no education (both $p<0.01$). However, when other measures of socioeconomic status are added to the model, those odds ratios move closer to equality (0.86 and 0.79) and neither is statistically significantly different from 1.0 (SES-only model, Table 3). In other words, the other SES factors account for a substantial portion of the association between mother's education and small size at birth.

Separate regression models with only household composition or only environmental factors (not reported) confirm this argument: the odds ratios on mother's education lose their statistical significance only when socioeconomic status is included in the models, implying that neither household composition nor environmental factors reduce the size and statistical significance of the odds ratio for mother's education as much as does socioeconomic status.

Next, we compare odds ratios from the series of multivariate models for stunting, shown in Table 4. In the Baseline model, risk of stunting exhibits a steep decline as mother's education increases, with OR=0.73 and 0.32 for children of women with primary and secondary education, when each is compared to no education; both $p<0.01$. Introduction of controls for other measures of socioeconomic status again moves those odds ratios closer to 1.0 (0.88 and 0.59; SES-only model, Table 4), and only children born to mothers with secondary education remain statistically significantly less likely to be low height-for-age than those born to mothers with no education. Put differently, inclusion of controls for wealth, agricultural occupation, type of mother's earnings, and father's education reduces the difference in risk of child stunting compared to the no education group by 56 percent for those with primary education, and by 40 percent for those with secondary education.[4] In subsequent models that introduce controls for household composition and environmental factors, the odds ratios on stunting according to mother's education remain virtually unchanged from those in the SES-only model.

Consistent with the bivariate pattern, there is no statistically significant difference in risk of wasting according to mother's educational attainment in any of the multivariate models (Table 5). The pattern for children who are classified as wasted differs from what was expected, with children of mothers having primary education showing slightly lower odds of being low weight-for-height compared to children of uneducated mothers, while children of mothers with secondary schooling have higher relative odds of being wasted.

[4]The change in risk between models = [(1.0 – OR from Model A) – (1.0 – OR from Model B)]/(1.0 – OR from Model A) * 100. See Miller (2005, 229) for further discussion of this calculation of the change in excess risk across models based on odds ratios.

Table 3. **Children's Small Birth Size: Odds Ratios and Standard Errors for Effects of Mother's Education, Socioeconomic Status, Household Composition, and Environmental Characteristics, 2005 Cambodia DHS** (reference groups in parentheses)

Characteristics	Baseline		SES-only		SES & HH comp		SES & environ		Full model	
Mother's education (reference: no education)										
Primary school	0.68*	(0.09)	0.86	(0.13)	0.86	(0.13)	0.87	(0.13)	0.86	(0.13)
Secondary or higher	0.47*	(0.11)	0.79	(0.20)	0.79	(0.19)	0.78	(0.20)	0.78	(0.19)
Male child	0.85	(0.10)	0.84	(0.10)	0.84	(0.10)	0.83	(0.10)	0.82	(0.10)
Proxies for socioeconomic status										
Wealth index (reference: 1st quintile)										
2nd quintile			0.97	(0.17)	0.96	(0.17)	1.01	(0.18)	1.01	(0.18)
3rd quintile			0.99	(0.18)	0.99	(0.18)	1.05	(0.20)	1.05	(0.20)
4th quintile			0.89	(0.20)	0.88	(0.19)	0.92	(0.23)	0.92	(0.23)
5th (richest) quintile			0.88	(0.23)	0.86	(0.22)	0.96	(0.33)	0.94	(0.32)
Type of mother's earnings (reference: unpaid)										
Cash only			0.77	(0.14)	0.78	(0.14)	0.75	(0.14)	0.76	(0.14)
Cash and in-kind			1.43	(0.39)	1.47	(0.40)	1.43	(0.39)	1.47	(0.40)
In-kind only			0.77	(0.19)	0.79	(0.20)	0.76	(0.19)	0.77	(0.19)
Mother's occupation in agriculture			0.85	(0.19)	0.85	(0.19)	0.84	(0.19)	0.85	(0.19)
Father's occupation in agriculture			1.30	(0.21)	1.30	(0.21)	1.24	(0.20)	1.24	(0.20)
Father's education (reference: no education)										
Primary school			0.56*	(0.09)	0.56*	(0.09)	0.58*	(0.09)	0.58*	(0.09)
Secondary or more			0.45*	(0.09)	0.44*	(0.09)	0.49*	(0.10)	0.48*	(0.10)

Continued

Table 3—*Continued*

Characteristics	Baseline	SES-only	SES & HH comp		SES & environ		Full model	
Household composition								
Number of children < 5 yrs.			1.04	(0.10)			1.05	(0.10)
Number of children 5–12 yrs			0.97	(0.06)			0.96	(0.06)
Number of children 13–17 yrs.			0.93	(0.08)			0.93	(0.08)
Four + adults in HH (reference: 1–3)			1.17	(0.18)			1.20	(0.19)
Female-headed household			0.97	(0.25)			1.01	(0.26)
Mother's age at first birth, years (reference: 15–19)								
20–24			0.95	(0.13)			0.95	(0.13)
25+			0.84	(0.17)			0.87	(0.18)
Household environmental factors								
Mother smokes cigarettes					1.40	(0.29)	1.40	(0.30)
Has improved toilet					1.36	(0.34)	1.36	(0.34)
Has clean drinking water					0.77	(0.11)	0.77	(0.11)
December or January measured weight & height (reference: other months)					1.03	(0.14)	1.03	(0.14)
Geographic region (reference: other rural)								
Phnom Penh					0.43†	(0.17)	0.42†	(0.17)
Other urban					1.25	(0.23)	1.27	(0.23)
Wald chi-square	15.48*	56.26*	65.72*		68.34*		78.24*	
Degrees of freedom for model	3	14	21		20		27	

* means p<0.01, † means p<0.05.

DHS = Demographic and Health Survey; HH = household; SES = socioeconomic status.

Notes: Small birth size is "very small" or "smaller than average" at birth according to mothers' assessments. Weighted to national level with weights provided by the 2005 Cambodia DHS.

Source: Logistic regressions on the sample of 3,542 children aged 0–59 months, 2005 Cambodia DHS (NIPH/NIS/ORC 2006).

Table 4. **Children's Stunting: Odds Ratios and Standard Errors for Effects of Mother's Education, Socioeconomic Status, Household Composition, and Environmental Characteristics, 2005 Cambodia DHS** (reference groups in parentheses)

Characteristics	**Baseline**		**SES-only**		**SES & HH comp**		**SES & environ**		**Full model**	
Mother's education (reference: no education)										
Primary school	0.73*	(0.08)	0.88	(0.10)	0.88	(0.10)	0.88	(0.10)	0.88	(0.10)
Secondary or higher	0.32*	(0.05)	0.59*	(0.10)	0.59*	(0.10)	0.61*	(0.11)	0.60*	(0.11)
Male child	1.11	(0.10)	1.11	(0.10)	1.10	(0.10)	1.11	(0.10)	1.10	(0.10)
Age of child, yrs. (reference: 4)										
<1	0.14*	(0.02)	0.13*	(0.02)	0.13*	(0.02)	0.13*	(0.02)	0.13*	(0.02)
1	0.84	(0.11)	0.82	(0.11)	0.83	(0.11)	0.82	(0.11)	0.83	(0.11)
2	0.73†	(0.10)	0.72†	(0.10)	0.74†	(0.10)	0.71†	(0.10)	0.73†	(0.10)
3	0.88	(0.12)	0.85	(0.11)	0.87	(0.12)	0.84	(0.11)	0.86	(0.11)
Proxies for socioeconomic status										
Wealth index (reference: 1st quintile)										
2nd quintile			0.83	(0.11)	0.85	(0.11)	0.87	(0.11)	0.89	(0.11)
3rd quintile			0.74†	(0.10)	0.77	(0.10)	0.80	(0.11)	0.82	(0.11)
4th quintile			0.69†	(0.11)	0.71†	(0.12)	0.78	(0.13)	0.81	(0.14)
5th (richest) quintile			0.33*	(0.07)	0.33*	(0.07)	0.40*	(0.10)	0.41*	(0.11)
Type of mother's earnings (reference: unpaid)										
Cash only			0.96	(0.13)	0.97	(0.13)	0.95	(0.13)	0.97	(0.13)
Cash and in-kind			0.89	(0.19)	0.88	(0.19)	0.89	(0.19)	0.89	(0.19)
In-kind only			0.97	(0.16)	0.99	(0.17)	0.99	(0.17)	1.00	(0.17)
Mother's occupation in agriculture			0.86	(0.12)	0.85	(0.12)	0.84	(0.12)	0.83	(0.12)
Father's occupation in agriculture			1.13	(0.13)	1.14	(0.13)	1.12	(0.13)	1.13	(0.13)
Father's education (reference: no education)										
Primary school			0.84	(0.11)	0.87	(0.12)	0.90	(0.12)	0.93	(0.12)
Secondary or more			0.69†	(0.11)	0.70†	(0.11)	0.75	(0.12)	0.77	(0.12)

Continued

Table 4—*Continued*

Characteristics	Baseline	SES-only	SES & HH comp		SES & environ		Full model	
Household composition								
Number of children < 5 yrs.			1.17†	(0.09)			1.15	(0.09)
Number of children 5–12 yrs			1.10†	(0.05)			1.09	(0.05)
Number of children 13–17 yrs.			0.99	(0.06)			0.98	(0.06)
Four + adults in HH (reference: 1–3)			1.08	(0.13)			1.08	(0.13)
Female-headed household			1.06	(0.19)			1.09	(0.20)
Mother's age at first birth, years (reference: 15–19)								
20–24			1.18	(0.12)			1.20	(0.12)
25+			1.17	(0.17)			1.18	(0.17)
Household environmental factors								
Mother smokes cigarettes					1.94*	(0.38)	1.87*	(0.37)
Has improved toilet					0.83	(0.15)	0.82	(0.15)
Has clean drinking water					0.93	(0.09)	0.93	(0.10)
December or January measured weight & height (reference: other months)					0.97	(0.09)	0.97	(0.09)
Geographic region (reference: other rural)								
Phnom Penh					0.91	(0.27)	0.88	(0.26)
Other urban					1.18	(0.16)	1.16	(0.16)
Wald chi-square	212.94*	251.74*	280.41*		266.70*		291.47*	
Degrees of freedom for model	7	18	25		24		31	

* means p<0.01, † means p<0.05.

DHS = Demographic and Health Survey; HH = household; SES = socioeconomic status.

Notes: Stunting refers to children whose height-for-age is more than two standard deviations below the reference median for children of the same gender (z-score below –2.0). Weighted to national level with weights provided by the 2005 Cambodia DHS.

Source: Logistic regressions on the sample of 3,542 children aged 0–59 months, 2005 Cambodia DHS (NIPH/NIS/ORC 2006).

Table 5. **Children's Wasting: Odds Ratios and Standard Errors for Effects of Mother's Education, Socioeconomic Status, Household Composition, and Environmental Characteristics, 2005 Cambodia DHS** (reference groups in parentheses)

Characteristics	Baseline		SES-only		SES & HH comp		SES & environ		Full model	
Mother's education (reference: no education)										
Primary school	0.89	(0.17)	1.06	(0.22)	1.04	(0.21)	1.08	(0.22)	1.06	(0.22)
Secondary or higher	1.14	(0.27)	1.53	(0.43)	1.52	(0.43)	1.51	(0.43)	1.51	(0.44)
Male child	0.98	(0.15)	0.97	(0.15)	0.97	(0.15)	0.97	(0.15)	0.97	(0.15)
Age of child, yrs. (reference: 4)										
<1	1.07	(0.31)	1.13	(0.33)	1.13	(0.33)	1.14	(0.34)	1.15	(0.34)
1	2.60*	(0.63)	2.69*	(0.65)	2.61*	(0.63)	2.64*	(0.64)	2.57*	(0.63)
2	1.35	(0.37)	1.37	(0.38)	1.32	(0.37)	1.36	(0.38)	1.32	(0.37)
3	1.31	(0.37)	1.28	(0.36)	1.24	(0.35)	1.26	(0.35)	1.22	(0.34)
Proxies for socioeconomic status										
Wealth index (reference: 1st quintile)										
2nd quintile			1.26	(0.28)	1.22	(0.27)	1.25	(0.27)	1.21	(0.26)
3rd quintile			0.73	(0.20)	0.69	(0.19)	0.73	(0.20)	0.69	(0.19)
4th quintile			0.70	(0.20)	0.65	(0.19)	0.61	(0.18)	0.57	(0.17)
5th (richest) quintile			0.87	(0.28)	0.83	(0.26)	0.69	(0.27)	0.67	(0.26)
Type of mother's earnings (reference: unpaid)										
Cash only			1.54	(0.37)	1.54	(0.37)	1.53	(0.37)	1.53	(0.37)
Cash and in-kind			1.23	(0.45)	1.21	(0.43)	1.20	(0.43)	1.18	(0.42)
In-kind only			0.98	(0.31)	0.99	(0.31)	0.98	(0.31)	1.00	(0.31)
Mother's occupation in agriculture			1.02	(0.26)	0.98	(0.25)	1.04	(0.27)	1.00	(0.26)
Father's occupation in agriculture			1.60†	(0.34)	1.57†	(0.33)	1.67†	(0.36)	1.64†	(0.35)
Father's education (reference: no education)										
Primary school			0.66	(0.15)	0.68	(0.15)	0.65	(0.16)	0.67	(0.16)
Secondary or more			0.79	(0.22)	0.81	(0.22)	0.78	(0.23)	0.79	(0.23)

Continued

Table 5—*Continued*

Characteristics	Baseline	SES-only	SES & HH comp		SES & environ		Full model	
Household composition								
Number of children < 5 yrs.			0.79	(0.11)			0.80	(0.12)
Number of children 5–12 yrs			1.15	(0.08)			1.14	(0.08)
Number of children 13–17 yrs.			0.88	(0.10)			0.89	(0.10)
Four + adults in HH (reference: 1–3)			1.23	(0.27)			1.20	(0.26)
Female-headed household			0.87	(0.31)			0.86	(0.31)
Mother's age at first birth, years (reference: 15–19)								
20–24			0.98	(0.17)			0.93	(0.16)
25+			1.12	(0.27)			1.10	(0.26)
Household environmental factors								
Mother smokes cigarettes					1.20	(0.40)	1.18	(0.39)
Has improved toilet					1.38	(0.36)	1.35	(0.36)
Has clean drinking water					1.09	(0.19)	1.09	(0.19)
December or January measured weight & height (reference: other months)					0.58*	(0.10)	0.58*	(0.10)
Geographic region (reference: other rural)								
Phnom Penh					0.90	(0.36)	0.90	(0.36)
Other urban					1.15	(0.24)	1.16	(0.25)
Wald chi-square	26.59*	49.55*	57.45*		69.01*		76.20*	
Degrees of freedom for model	7	18	25		24		31	

* means p<0.01, † means p<0.05.

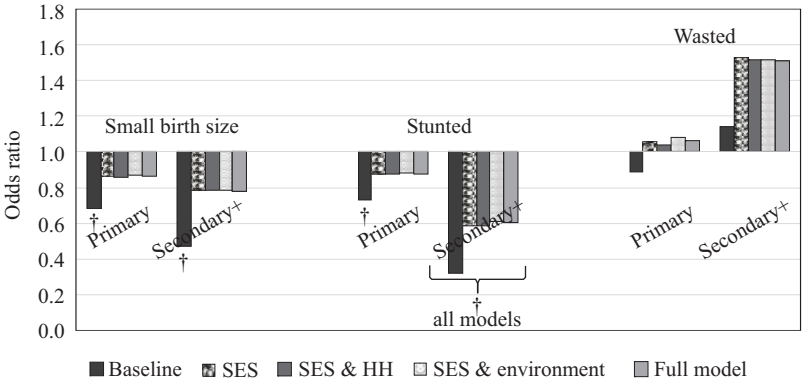
DHS = Demographic and Health Survey; HH = household; SES = socioeconomic status.

Notes: Wasting refers to children whose weight-for-height is more than two standard deviations below the reference median for children of the same gender (z-score below –2.0). Weighted to national level with weights provided by the 2005 Cambodia DHS.

Source: Logistic regressions on the sample of 3,542 children aged 0–59 months, 2005 Cambodia DHS (NIPH/NIS/ORC 2006).

In order to highlight the key results of interest, the coefficients on mother's education for each of the models and all three nutritional outcomes are shown in the Figure. Children of mothers with secondary schooling have lower odds of being stunted compared to children of mothers with no education, but neither small size at birth nor wasting are statistically significantly associated with mother's education in any of the multivariate models after the Baseline specification. Moreover, changes in odds ratios for each of the child nutritional status outcomes are few and small across the series of models (compare the heights of bars within the cluster for each child nutrition outcome) once SES measures are included in the specification.

Odds Ratios of Children's Poor Nutritional Status by Mother's Education from a Series of Nested Models, 2005 Cambodia DHS



† denotes p < .05 compared to children of women with no education.
Secondary+ represents secondary schooling and above.
DHS = Demographic and Health Survey; HH = Household Composition;
OR = Odds Ratio; SES = Socioeconomic Status.
Notes: Each bar shows the estimated odds ratio of being small at birth, stunted, or wasted for children in the noted mother's education group, compared to mothers with no education, from multiple logistic regressions. The full results are presented in Tables 3–5. Weighted to national level with weights provided by the 2005 Cambodia DHS. OR < 1.0 corresponds to lower risk than the reference category; OR > 1.0 corresponds to a higher risk.
Source: Authors' calculations based on NIPH/NIS/ORC (2006).

In terms of the other covariates, several interesting patterns emerge. The risk of stunting is positively associated with age of child, with children under one year old having a tenth the odds of stunting ($p<0.01$) and two-year-old children having about three-quarters the odds of stunting compared to four-year-old children ($p<0.05$; Table 4). For wasting, one-year-old children are at particularly high risk of wasting (OR=2.6, $p<0.01$; Table 5), most likely due to the cessation of breastfeeding and transition to exclusive reliance on solid foods. Father's education is inversely associated with each of the three child nutritional status indicators. In the case of small birth size, father's education

retains statistical significance even in the Full specification: Children of fathers with primary education and of fathers with secondary or higher education have 58 percent and 48 percent of the odds of being small at birth as children with uneducated fathers ($p<0.01$; Full model, Table 3).

Prevalence of child stunting declines markedly with increasing household wealth, with children from households in the richest quintile having 33 percent odds of stunting as those in the poorest quintile (Table 4). Introduction of controls for household composition and environmental factors attenuates those odds ratios somewhat (from 0.33 in the SES-only model to 0.41 in the Full model; both $p<0.01$), suggesting that the association between wealth and long-term child growth operates partially through provision of more favorable demographic circumstances and less noxious environments.

Chances of low height-for-age increase with number of children in the household under 5 years of age and those aged 5 to 12, but are not associated with the number of children aged 13 to 17 in the household (SES & HH comp model, Table 4). The number of children in any of these age groups is not statistically significantly associated with either small size at birth or wasting. The other household composition measures—number of adults in the household, female headship, and mother's age at first birth—are not associated with any of the indicators of poor nutritional status.

Maternal smoking is associated with increased chances of stunting (OR=1.94; SES & environ model, Table 4). Treating water before drinking and cooking is associated with a decreased risk of small size at birth ($p=.06$), but is not a statistically significant predictor of the other child nutrition outcomes. In addition, children with fathers who work in agriculture have about 60 percent greater risk of wasting compared to children with fathers in other occupations ($p<0.05$). Children who were weighed and measured in December or January had lower odds of wasting than those measured at other times of the year, but season was not associated with either small size at birth or stunting.

In the final hypothesis test, we tested for variation by mother's education in the gaps between boys and girls in nutritional status outcomes. To do so, we tried an alternative version of the model that included interaction terms between male child and mother's education; none of these interactions were statistically significant even before controls for socioeconomic status were included (not shown).

V. CONCLUSION

A. Summary of Findings

This study has used data from the 2005 Cambodia Demographic and Health Survey to examine the relationship between nutritional status of children under age five and their mother's education. In bivariate tabulations, mother's education was strongly inversely associated with risks of both small birth size and stunting, but not with wasting. Stunting, or low height-for-age, is an indicator of long-term nutritional and health history that captures chronic deprivation such as that experienced by people in low socioeconomic households. The pattern of declining incidence of stunting by mother's education in Cambodia is consistent with patterns observed in many other developing countries (Mukuria et al. 2005). In contrast, wasting (low weight-for-height) is an indicator of short-term nutrition and health, and tends to reflect recent illness or nutritional deprivation such as that due to catastrophic events, including famine and epidemic, that can cut across all socioeconomic levels. The pattern for wasting concurs with arguments found in several other studies (e.g., Joshi 1994, Katahoire et al. 2004, Frost et al. 2005) that wasting is influenced less by maternal characteristics than is stunting. One explanation is that mother's education is of limited effectiveness in preventing illness such as diarrhea when there are widespread sources of infection. Surprisingly, neither water treatment nor improved toilet were associated with odds of wasting, although season in which the child was measured showed the expected lower odds during the rice harvest season, when food is plentiful, than in the rainy season (Ross 1987).

A series of multivariate models were estimated to test for mechanisms linking mother's education and children's nutritional status. Sizable bivariate associations were found between mother's education and numerous indicators of socioeconomic status, including father's education, household wealth, type of occupation, and type of earnings. Once these socioeconomic status variables were introduced into the multivariate specifications, mother's education was no longer a statistically significant determinant of children's size at birth, but it retained an inverse association with a child's risk of being stunted. Based on the full multivariate results, children born to women with at least secondary education were roughly one-third less likely than those with uneducated mothers to be stunted—a substantial gradient in this indicator of long-term nutritional deprivation.

Results also indicated only small, substantively insignificant changes in odds ratios for each of the nutritional status outcomes as blocks of variables

representing determinants of child health were added to the specification with mother's education and socioeconomic status. This pattern suggests that once socioeconomic status was controlled, household composition and environmental factors played relatively small roles in explaining the association between mother's education and child nutritional outcomes. Although several of these proximate determinants of health were statistically significantly associated with one or more of the child nutritional outcomes, none of them appeared to mediate the association between mother's education and those outcomes.

In addition, the current analysis revealed no evidence of son preference in indicators of children's nutritional status, either in the bivariate analysis or in the multivariate analysis of whether there might be gender differences in how mother's education relates to each of the child nutrition measures. This finding of no statistically significant differences between boys and girls in measures of nutritional status is consistent with several earlier reviews of child nutrition studies (Marcoux 2002, Sommerfelt and Arnold 1998). In addition, a review of 168 quantitative studies in Haddad et al. (1996) found scarce evidence of discrimination against girls in intra-household food allocation; the few studies that did find a pro-male bias were primarily for South Asia (India, Nepal, Bangladesh, and Pakistan). Mishra et al. (2004)—who also found no consistent patterns of statistically significant bias against girls in feeding, immunization, seeking treatment, and nutritional status in India during the 1990s—attributed their findings to the lack of universal discrimination against girls, the role of birth order and sibling composition, and the way that girls cope with food deprivation compared to boys. Our finding that a child's gender is not a statistically significant predictor of nutritional status is also concordant with results in Fuse (2008) indicating that more than half of Cambodian respondents favor gender balance in the composition of their children.

This study has provided new evidence from one of the poorest countries in Asia on the channels through which mother's education operates to affect different indicators of short-term and longer-term child health and nutritional status. Up-to-date statistical evidence on the benefits of mother's education is particularly important given the heavy weight placed on educating girls in international policy dialogues. The rich source of information provided by the 2005 Cambodia Demographic and Health Survey allowed us to control for a host of proximate determinants of health to reinforce the paper's arguments about the importance of mother's education. However, data for the topic modules on women's autonomy and children's height and weight were collected for only a small overlapping group of women in the sample. This

survey-design limitation prevented the paper from exploring how mother's education operates through women's autonomy and bargaining power within the household to affect children's nutritional status.

B. Policy Implications

A better understanding of the channels through which mother's education affects children's nutritional status can contribute to more effective policy responses to reduce undernutrition among children, which in turn can lead to profound and long-term benefits for individuals and for society as a whole. In support of this argument, Victora et al. (2008) conducted a systematic review of 28 previous studies chosen for high methodological quality and adequate statistical power to evaluate the effects of early childhood nutritional indicators on adult height, school achievement, labor market outcomes, and a range of adult health and illness measures. They also used data from studies that prospectively traced birth cohorts into early adulthood in five developing countries—Brazil, Guatemala, India, Philippines, and South Africa—to estimate models of adult outcomes, controlling for age, parent's education, and early childhood socioeconomic status. In both their literature review and their own statistical analysis, they found low height-for-age and weight-for-age at 2 years of age to be associated with long-term impairment in educational attainment, school performance, adult height, productivity, and earnings; they did not analyze weight-for-height as a child nutritional indicator. They concluded that nutritional deprivation among children is a potentially important mechanism linking the health outcomes of successive generations, as undernourished girls are more likely to grow into short adults, who are then at increased risk of bearing small babies.

This is a downward cycle that Cambodia can ill afford, given the progress the country still needs to make in achieving the Millennium Development Goals (MDGs) related to maternal and child health. In the most recently-available official review of progress in achieving Cambodia's MDGs between the mid-1990s and 2004, the Ministry of Planning (2005) concluded that the country has had success in some but not all areas. Both infant mortality and under-five mortality (MDG 4) fell below target levels, with reductions of about a third in each of those indicators. Despite these gains, Cambodia's infant mortality rates rank among the highest in Asia. Progress toward maternal health (MDG 5) was mixed, with antenatal care use approaching the target of 60 percent, but maternal mortality remaining alarmingly high at 540 per 100,000 live births—one of the highest rates in the region (World Bank 2007). Indirect estimates suggest a substantial reduction

between the mid-1990s and 2004 in the percentage of the population that falls below the food poverty line (MDG 1b). However, economic growth and public investment occurred principally in urban and more accessible rural areas, resulting in slower declines in poverty and hunger in remote rural areas (Ministry of Planning 2005).

For the MDGs to be achieved by the year 2015, reconstruction of the country's education and health systems infrastructure—in terms of both human resources and physical infrastructure—must remain a top priority following the widespread destruction that Cambodia sustained during the carpet bombing of the Viet Nam War and the Khmer Rouge genocide between 1975 and 1979 (Lanjouw et al. 1999, Bhushan et al. 2002). Another priority is greater funding for health services in the public sector, which remain underfunded compared to the private sector in terms of training and pay for health care workers (Heng and Key 1995). Greater emphasis on government contracting of health services to non-governmental organizations can also lead to improved access to health services by the poor and by those living in rural areas. Bhushan et al.'s (2002) analysis of the Cambodian government's pilot program to contract with non-governmental organizations for health care delivery found that over the two-and-a-half-year study period, the share of illnesses among low SES groups that were treated in public health care facilities increased over 10 times as much in areas under health care delivery contracts as in control areas, while childhood immunizations and use of antenatal care rose 2.5 to 3.0 times as much. However, these estimates probably overstate the changes attributed to contracting of health services because the analysis did not control for other contemporaneous changes. By reducing the illness burden for women and children, this alternative approach to service delivery can help improve children's growth and nutritional status.

Another policy reform that is backed by a growing amount of empirical evidence, especially from Latin American, is conditional cash transfers to women living in poverty. These programs tie cash transfers to improved nutrition for women of reproductive age, or to schooling and health care needs for their children. In a systematic review of results for the evaluation of schooling and health outcomes in the first generation of cash transfer programs in three countries, Rawlings and Rubio (2005) showed that these programs increased children's primary and secondary school enrollment rates, raised nutrition monitoring visits and immunization rates of children below the age of two, and lowered children's illness rates and the risk of nutritional deprivation. In Mexico, for example, children's illness rates fell by close to 5 percentage points for a reduction of about 12 percent below the baseline value, while

growth monitoring visits for children under age 2 increased by 25 percent to 60 percent.

Closely related, targeted scholarships can act like conditional transfer programs in increasing school enrollment. An evaluation of the Cambodian government's targeted scholarships program, which started in 2003–2004, indicated it raised school enrollment and attendance of girls who were moving up from primary school to secondary school by about 30 percentage points (Filmer 2008). Hence effective targeting can indeed help small budgets go a longer way. In addition, growth and investment need to become more rural-focused, with the adoption of deliberate policies to accelerate poverty reduction and reduce child hunger in the rural sector.

C. Directions for Future Research

The current findings suggest several important directions for future research: One direction is to examine the specific components of children's diets and to test whether mother's education influences intake of critical micronutrients for health and growth. A second avenue for research is to assess the extent to which more-educated mothers are empowered to make choices about their children's food and health care that increase their children's chances for optimal growth and nutritional status. A third direction is to examine how mother's stature and body mass index are associated with her children's nutritional status, again investigating both long-term and short-term patterns. Adult stature captures the mother's nutritional and illness history during her own growth and development, which in turn may affect her ability to nourish a fetus during gestation. Her body mass index, like measures of her children's wasting, captures short-term nutritional and illness history, and could provide useful insight into the nutritional picture of the household and food allocation among its members. A final research need is to assess the role of health care in children's nutritional outcomes by including measures of access to health care facilities.

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