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Household Food Insecurity Is Associated with Higher Child Undernutrition in Bangladesh, Ethiopia, and Vietnam, but the Effect Is Not Mediated by Child Dietary Diversity[1,2]

Disha Ali,[3]* Kuntal K. Saha,[4] Phuong H. Nguyen,[5] Michael T. Diressie,[3] Marie T. Ruel,[6] Purnima Menon,[7] and Rahul Rawat[6]

[3]International Food Policy Research Institute (IFPRI), Addis Ababa, Ethiopia; [4]IFPRI, Dhaka, Bangladesh; [5]IFPRI, Hanoi, Vietnam; [6]IFPRI, Washington, DC; and [7]IFPRI, New Delhi, India

Abstract

Household food insecurity (HFI) is a recognized underlying determinant of child undernutrition, but evidence of associations between HFI and child undernutrition is mixed. The purpose of this study was to investigate if HFI is associated with undernutrition in children aged 6–59.9 mo in Bangladesh (n = 2356), Ethiopia (n = 3422), and Vietnam (n = 3075) and if child dietary diversity (DD) mediated this effect. We used baseline survey data from the Alive & Thrive project. Logistic regression, adjusting for potential confounding factors, was used to determine the magnitude and significance of the association of HFI with stunting, underweight, and wasting. The mediating effect of child DD was tested by using a Sobel-Goodman mediation test. The prevalences of HFI were 66%, 40%, and 32% in Ethiopia, Vietnam, and Bangladesh, respectively. The prevalences of stunting, underweight, and wasting were higher in Bangladesh (47.1%, 43.7%, and 19.1%, respectively) and Ethiopia (50.7%, 27.5%, and 5.9%, respectively) than in Vietnam (20.7%, 15.8%, and 5%, respectively). In the adjusted models, the odds of being stunted or underweight were significantly higher for children in severely food-insecure households in Bangladesh (stunting OR: 1.36; 95% CI: 1.05, 1.76; underweight OR: 1.28; 95% CI: 0.99, 1.65) and Ethiopia (stunting OR: 1.48; 95% CI: 1.09, 2.00; underweight OR: 1.68; 95% CI: 1.22, 2.30) and in moderately food-insecure households in Vietnam (stunting OR: 1.39; 95% CI: 1.16, 1.65; underweight OR: 1.69; 95% CI: 1.28, 2.23). HFI was significantly associated with wasting in Bangladesh where close to 1 in 5 children demonstrated wasting. Child DD did not mediate the relation between HFI and undernutrition in any of the countries. Further research is recommended to investigate potential mediators in this pathway. J. Nutr. 143: 2015–2021, 2013.

Introduction

Child undernutrition remains alarmingly high in poor countries. In Bangladesh and Ethiopia, persistently high rates of child undernutrition are major public health concerns. In Vietnam, child undernutrition still remains high compared with other child health–related indicators. Bangladesh and Ethiopia, 2 low-income countries, and Vietnam, a middle-income country, are largely dependent on an agrarian economy. Yet, despite impressive progress in agriculture, poverty and hunger are widespread in Bangladesh (1) and Ethiopia (2). With rapidly increasing food prices, especially of rice, Vietnam has been classified as one of the hunger "hot spots" in the Asia-Pacific region (3).

The factors influencing child undernutrition are multifaceted. According to the UNICEF conceptual framework, household food insecurity (HFI)[8], inadequate childcare, and the lack of access to health, safe water, and sanitation services are the key underlying causes of child undernutrition (4). HFI is assumed to affect the nutritional status of children by compromising quantity and quality of dietary intake. However, empirical studies that examined the association between HFI and dietary intake of children showed mixed results (5–7). Additional studies are needed to examine the association between HFI and child undernutrition and potential pathways of the association, especially the role of dietary intake, to broaden our understanding of this relation in developing country contexts.

The Household Food Insecurity Access Scale (HFIAS) (8) and similar measures (9) based on a household's recent experience of food insecurity have been applied as indicators of HFI in

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* To whom correspondence should be addressed. E-mail: d.ali@cgiar.org.

[8] Abbreviations used: A&T, Alive & Thrive; DD, dietary diversity; FSNSP, Food Security and Nutrition Surveillance Project; HFI, household food insecurity; HFIAS, Household Food Insecurity Access Scale; IFHP, Integrated Family Health Project.

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developing countries but have also yielded mixed results on the association between HFI and child undernutrition (10–12). In Colombia, among participants of a food assistance program, the highest proportions of stunted and underweight children belonged to food-insecure households (11). In Pakistan, households that were food-insecure and experienced hunger were 3 times as likely to have a stunted child (10). In Nepal, however, no association was found between HFI and the nutritional status of children 6–23 mo of age (12). In a longitudinal study in rural Bangladesh, HFI was associated with growth of infants and young children aged 0–24 mo (13).

In this study, we examined the association between HFI and child undernutrition in Bangladesh, Ethiopia, and Vietnam by using the HFIAS as a measure of HFI to understand the extent to which the association is similar in these countries. We hypothesized that children in food-insecure households are more undernourished than their counterparts in food-secure households and that the association is independent of household wealth. Additionally, we hypothesized that child dietary diversity (DD) plays a mediating role in the association between HFI and undernutrition.

Participants and Methods

Data. We used data from the Alive & Thrive (A&T) baseline surveys conducted in Bangladesh, Ethiopia, and Vietnam between April and September 2010 as part of the evaluation of the impact of the A&T project on child undernutrition. The Bangladesh baseline survey included 4398 households in 20 selected subdistricts (*upazilas*) (14). The Ethiopia baseline survey included 2992 households from 75 enumeration areas in 2 regions (15). The Vietnam baseline survey included 4023 households in 40 communes from 4 provinces, including intervention and comparison communes (16). In this study, we included children 6–59.9 mo of age in Ethiopia and Vietnam, which yielded sample sizes of 2356 in Ethiopia and 3075 in Vietnam. For Bangladesh, we included 3422 children aged 6–47.9 mo; no data on children >48 mo of age were available. In Ethiopia, the survey sites were selected from districts where A&T was being implemented in collaboration with the Integrated Family Health Project (IFHP). The implementation sites for the IFHP were assigned by the federal government of Ethiopia and comparable to other areas where IFHP did not operate.

In Bangladesh, 20 subdistricts were chosen purposively for inclusion in the survey on the basis of the size, proximity, and equal representation of the major 5 administrative divisions of the country. From each subdistrict, 5 unions were randomly selected. Then, 2 villages were selected randomly from each of the selected unions, to yield a total of 200 villages from which survey households with children 0–47.9 mo of age were selected. In Ethiopia and Vietnam, households with children between 0 and 59.9 mo of age were selected by using a multistage cluster sampling method. The primary sampling unit was selected by using probability proportion to size—rural enumeration areas in Ethiopia and commune health centers in Vietnam. In all countries, 3 sampling frames were constructed from the household listing: 0–5.9 mo, 6–23.9 mo, and 24–59.9 mo (24–47.9 mo in Bangladesh). Children in each age category were randomly selected to reach the required number of children for that age. Households selected for 1 category of age were not included in the other categories, even if they had children of other age categories. Detailed descriptions of sampling are available elsewhere (14–16).

In Bangladesh and Vietnam, the survey was conducted between April and June, a period after harvest and not the peak season for food insecurity, whereas in Ethiopia, data collection took place during the long rainy season (June–September), when people usually suffer from severe food shortages.

A structured questionnaire following the UNICEF conceptual framework of causes of child undernutrition (4) was administered to the mothers of children. The questionnaire included modules on immediate determinants of child undernutrition, such as infant and young child feeding practices and childhood illnesses. It also contained several maternal and household questionnaire modules on underlying determinants of child undernutrition at maternal and household levels. The interviewers who collected data underwent rigorous classroom and field-based training on questionnaire administration. An experienced team of interviewers underwent a full training and standardization process for anthropometric measurements to ensure the precision and reliability of anthropometric measurements (17).

This study received ethical approval from institutional review boards in each country and the institutional review board at the International Food Policy Research Institute.

HFI. HFI was measured by using the Household Food Insecurity Access Scale (HFIAS) (8). The mothers were asked 9 questions related to the household's experience of food insecurity in the 30 d preceding the survey. These questions capture 3 main domains of HFI: *1*) anxiety and uncertainty about access (1 question), *2*) insufficient quality (3 questions), and *3*) insufficient quantity (5 questions). Each item starts with an occurrence question that identifies if the condition has been experienced in the household. An affirmative answer is then followed by a frequency-of-occurrence question to determine if the condition happened rarely (once or twice), sometimes (3–10 times), or often (>10 times) during the reference period. The responses were coded as 0 = never, 1 = rarely, 2 = sometimes, or 3 = often.

From these questions, we constructed 2 indicators of HFI: Household Food Insecurity Access Prevalence and HFIAS score, which ranges from 0 to 27. The distributions of the 9 questions used to derive these 2 indicators are presented in **Table 1**. The HFIAP indicator categorizes households into 4 levels of HFI: food-secure and mild, moderately, and severely food-insecure. Households are categorized as increasingly food-insecure as they responded affirmatively to more severe conditions and/or frequency of experiencing the conditions following steps described in

TABLE 1 HFI access-related conditions: household conditions in past 30 d in Bangladesh, Ethiopia, and Vietnam[1]

Condition	Bangladesh (*n* = 3422)	Ethiopia (*n* = 2356)	Vietnam (*n* = 3075)
Worried about not having enough food, %	26.9	57.0	33.9
Not able to eat the kinds of foods he/she preferred, %	27.8	55.6	19.8
Ate just a few kinds of food day after day, %	24.4	58.0	20.4
Ate food that he/she preferred not to eat, %	20.1	38.9	17.7
Ate a smaller meal than he/she felt was needed, %	19.7	44.7	9.8
Ate fewer meals in a day, %	12.3	39.1	6.4
No food at all, %	12.1	13.6	3.7
Went to sleep at night hungry, %	8.1	11.2	0.9
HFIAS score	2.7 ± 5.0	6.7 ± 6.7	2.3 ± 4.0

[1] Values are means ± SDs or percentages. HFI, household food insecurity; HFIAS, Household Food Insecurity Access Scale.

the manual (8). The HFIAS score was constructed by adding the values of the 9 questions ranging from 0 to 27. The reliability test of HFIAS score showed high internal consistency (Cronbach's α for Bangladesh = 0.93, Ethiopia = 0.90, and Vietnam = 0.81).

Anthropometric measurements. Weights of the children and their mothers were measured by using electronic weighing scales that were precise to 100 g. Locally manufactured collapsible length/height boards, which were precise to 1 mm, were used to measure recumbent length of the children <24 mo of age and standing height of children aged ≥24 mo and their mothers. Weight and length/height of the children were converted into height-for-age Z-scores, weight-for-age Z-scores, and weight-for-height Z-scores according to 2006 WHO child growth standards (18). Stunting, underweight, and wasting were defined as < −2 Z-scores of height-for-age, weight-for-age, and weight-for-height Z-scores, respectively.

Covariates. In the statistical models, known confounding factors at child, maternal, and household levels were adjusted for by choosing variables based on the UNICEF conceptual framework for child nutrition (4). Child DD was measured using WHO guidance (19). The indicator is based on a simple count of 7 food groups consumed in the past 24 h; to calculate minimum DD, a cutoff of >4 food groups was used. In addition, at the child level, 2 common childhood illnesses, diarrhea and acute respiratory illness, captured from the mother's recall in the 2 wk before the survey, were also adjusted for because of their recognized negative association with child nutritional status. Because women's educational levels varied across the 3 countries, we applied different cutoffs suitable for each country. The reference group in Vietnam was "primary education," whereas the reference group in Bangladesh and Ethiopia was "no schooling." Maternal height, an indicator of genetic endowment and intergenerational consequences of undernutrition, was controlled for in the model and included as a dichotomous variable (reference group: >145 cm).

At the household level, household size, an indicator of food allocation, and wealth (measured by a wealth index) were adjusted for. It can be argued that there may be collinearity between wealth and HFI, especially in relation to the food-purchasing capability of a household. However, the wealth index created in this study captured other dimensions of current wealth, such as assets accumulated over time, access to safe water and sanitation, and living conditions. Hence, we treated the wealth index as a potential confounding factor, which may exert at least part of its effect on child nutrition status independently of HFI.

Wealth indexes were constructed separately for each country by using principal components analysis (20) from a number of variables including ownership of house and land, quality of dwelling (e.g., house construction materials), access to services (water, electricity, sanitation, etc.), and a set of household assets (21,22). The wealth index was then used to categorize households into quintiles, from poorer (quintile 1) to wealthier (quintile 5).

Statistical analysis. Descriptive, bivariate, and multivariate analyses were carried out by using Stata 12 (23). The association between undernutrition and 4 categories of HFI (food-secure, mild food-insecurity, moderate food-insecurity, and severe food-insecurity) were assessed in the following 3 logistic regression models: *1*) unadjusted model, *2*) model adjusted for all confounding factors except for wealth index, and *3*) model presenting the effect of HFI on child undernutrition after adjusting for all potential confounding factors including the wealth index. All regression models were adjusted for sample clustering using the *cluster* command in Stata (23). Separate analyses were conducted for each country.

We examined the mediating effect of child DD (as a continuous variable) in the association between HFI and child undernutrition in 2 ways. First, we included child DD in our multivariate models (models 2 and 3) for 3 countries to see if the ORs for HFI were attenuated with this inclusion. Second, we estimated the proportion of the direct association between HFI and child undernutrition that was mediated through child DD by using a Sobel-Goodman mediation test.

Collinearity between HFI and wealth index was examined by looking at the tolerance and variance inflation factor values (the variance inflation factor was found to be <2 in all 3 countries: Bangladesh = 1.7, Ethiopia = 1.1, and Vietnam = 1.5), which were within the acceptable ranges and indicated that these variables were not collinear. The test for Pearson correlation yielded a moderate level of correlation between HFI and the wealth index (Bangladesh, −0.45; Ethiopia, −0.25; and Vietnam, −0.40). Therefore, we did not exclude the wealth index from the full model on the basis of these tests.

Results

Child, maternal, and household characteristics. Child, maternal, and household characteristics are presented in **Table 2**. Nearly half of the surveyed children in Bangladesh and Ethiopia and one-fifth in Vietnam were stunted. The prevalence of underweight and wasting were highest in Bangladesh (44% and 19%, respectively), followed by Ethiopia and Vietnam. In Ethiopia, more than a quarter of the children were underweight, but the prevalence of wasting was low (6%). The prevalences of underweight and wasting were lowest in Vietnam at 16% and 5%, respectively.

Approximately one-quarter of households in Bangladesh and Vietnam and nearly half of households in Ethiopia were moderately to severely food-insecure. There were also differences between the countries in relation to mean household size,

TABLE 2 Child, maternal, and household characteristics of participants in Bangladesh, Ethiopia, and Vietnam[1]

	Bangladesh (*n* = 3422)	Ethiopia (*n* = 2356)	Vietnam (*n* = 3075)
Dependent variable, %			
Child stunting	47.1	50.7	20.7
Child underweight	43.7	27.5	15.8
Child wasting	19.1	5.9	5.0
Independent variable, %			
Food security			
Food-secure	67.6	33.6	59.7
Mildly food-insecure	6.5	16.9	16.5
Moderately food-insecure	12.5	34.1	17.5
Severely food-insecure	13.4	15.4	6.3
Covariates			
Household characteristics			
Household size, *n*	5.1 ± 1.9	5.9 ± 2.0	4.7 ± 1.4
Mothers' characteristics			
Age, *y*	27.3 ± 6.1	29.5 ± 6.5	30.0 ± 5.4
Education, %			
No schooling	27.6	68.9	—
Primary school	29.6	27.3	16.4
Secondary school	40.4	5.9	51.8
High school	2.4	—	20.0
College or higher	—	—	11.8
Short stature (<145 cm), %	13.0	2.4	6.2
Children's characteristics			
Age, *mo*	27.8 ± 11.4	29.9 ± 14.6	31.3 ± 15.3
Sex, *% female*	47.9	47.9	47.4
ARI, %	33.0	20.0	17.6
Diarrhea, %	8.0	16.3	9.0
Child DD (food groups, range: 0–7)	3.5 ± 1.5	2.0 ± 1.0	4.8 ± 1.4
Consumed ≥ 4 food groups, %	48.4	7.8	83.2

[1] Values are means ± SDs or percentages. ARI, acute respiratory illness; DD, dietary diversity; —, no observation.

maternal educational attainment, maternal height, and prevalence of diarrhea and acute respiratory illness.

The prevalence of stunting and underweight was lowest in food-secure households and highest in severely food-insecure households in Bangladesh and Ethiopia and in moderately food-insecure households in Vietnam. The differences in undernutrition prevalence by HFI category were highly significant ($P <$ 0.001) (**Table 3**). In all 3 countries, increasing severity of food insecurity was associated with a higher prevalence of stunting. A similar pattern was observed for wasting in Bangladesh but not in Ethiopia and Vietnam where wasting was much less prevalent. The percentage of children who had achieved minimum DD was also strongly associated with HFI category in all 3 countries in the expected direction: the more food-insecure the households, the less likely children achieved minimum DD. In addition, more child illnesses were observed in food-insecure households.

Multivariate analysis of the association of HFI with stunting, underweight, and wasting. In unadjusted models (model 1, **Table 4**), HFI was significantly associated with stunting and underweight in all 3 countries but with wasting only in Bangladesh and Vietnam. Wasting was associated with severe food insecurity in Bangladesh and with moderate food insecurity in Vietnam. The results clearly indicate a dose-response relation of HFI with 3 child undernutrition indicators in all 3 countries, yielding higher ORs with increasing severity of HFI.

After adjusting for all hypothesized confounding factors except for the wealth index (model 2, Table 4), moderate and severe food insecurity were significantly associated with stunting and underweight in all 3 countries and with wasting in Bangladesh and Vietnam. When the wealth index was included in the models (model 3, Table 4), all of these associations remained significant. However, the magnitude of the associations and levels of significance decreased somewhat when the wealth index was included in the models, particularly in Bangladesh and Vietnam.

We observed that including child DD in the models negligibly attenuated the effects (e.g., in Bangladesh, the OR for stunting decreased from 1.37 to 1.35 when included in model 3) and the associations between HFI and undernutrition remained the same across 3 countries. The proportions of the total effect mediated by DD were also minimal in the models adjusted for all covariates in all 3 countries (results not shown).

Discussion

In our study, HFI was highly prevalent in Bangladesh, Ethiopia, and Vietnam and was significantly associated with stunting and underweight in all 3 countries. In Bangladesh, where the prevalence of wasting was significantly higher than in Ethiopia and Vietnam, affecting 1 in 5 children, HFI was also significantly associated with wasting. Children in food-insecure households had 1.5 greater odds of being stunted than children in food-secure households in all 3 countries. The results from this study also demonstrated that the magnitude of association between HFI and child undernutrition, although attenuated, remains significant with the inclusion of household wealth. This suggests that the association between HFI and child undernutrition is, at least to some extent, independent of household wealth. The results also highlight the fact that programs aimed at improving child nutrition in poor settings are likely to be more successful if they include explicit interventions to enhance household food security.

Similar associations between HFI and child undernutrition were found in other studies in Bangladesh (24), Colombia (11), and Pakistan (10). A study in Nepal (12), however, showed no association between HFI and child undernutrition, and the authors argued that several factors beyond food security may play important roles, including maternal education and knowledge, maternal nutritional status, access to health care, and intrahousehold food allocation. A younger age group (6–24 mo) of children in the Nepal study may be another reason for the lack of an association. Many of these proposed factors were controlled for in our analysis, and we found a consistently significant association between HFI and child undernutrition.

We postulated, on the basis of the UNICEF framework, that food insecurity exerted its effects on undernutrition through its negative effects on dietary intake (25–27). This pathway is highly plausible in our study, given that in our study bivariate analyses showed that HFI was strongly associated with a lower percentage of children achieving minimum DD in all 3 countries. Our tests for the mediating effect of child DD in the association between HFI and child undernutrition showed that child DD did not significantly mediate the total effect of the association between HFI and child undernutrition. Although this finding was unexpected, we offer several explanations. There is an inherent limitation of the data due to the cross-sectional nature of the study, which restricts us in establishing the sequence of events. HFI was assessed on the basis of the household's experience of food insecurity within 30 d before the survey, child DD was measured on the previous day's recall, and anthropometric measurements were taken at the time of the survey. The anthropometric measurements reflected children's nutritional status being built up over some period of time. Thus, whereas HFI might affect the previous day's food intake, recent child DD was unlikely to demonstrate its influence on

TABLE 3 Prevalence of child undernutrition, infant and young child feeding practices, and child morbidity by HFI category[1]

	Bangladesh				Ethiopia				Vietnam			
	Food-secure	Mild HFI	Moderate HFI	Severe HFI	Food-secure	Mild HFI	Moderate HFI	Severe HFI	Food-secure	Mild HFI	Moderate HFI	Severe HFI
Stunting	41.7***	54.5	55.2	62.8	45.5***	49.6	53.6	56.9	17.3***	23.2	27.8	25.6
Underweight	39.6***	49.5	48.2	56.9	22.4***	27.9	28.6	30.6	12.1***	19.8	22.7	19.7
Wasting	17.7***	20.4	18.7	25.4	5.3	6.4	5.9	6.4	4.5	4.6	7.1	5.7
Minimum DD	53.4***	41.2	41.5	33.0	9.1**	10.1	7.3	3.3	87.1***	81.0	75.1	73.7
Diarrhea	6.8***	9.4	9.9	11.7	13.4***	13.7	16.7	24.4	7.2***	12.1	11.2	12.6
ARI	30.3***	29.6	40.6	41.1	15.1***	15.1	22.3	30.3	14.1***	18.8	23.9	29.4

[1] Values are percentages. The prevalence of various categories of HFI was compared by using chi-square test. Different from food-insecure households: $^{**}P < 0.01$, $^{***}P <$ 0.001. ARI, acute respiratory illness; DD, dietary diversity; HFI, household food insecurity.

TABLE 4 Associations of HFI with stunting, underweight, and wasting in children aged 6–59 mo in Bangladesh, Ethiopia, and Vietnam[1]

	Model 1[2]	Model 2[3]	Model 3[4]
Stunting			
Bangladesh			
Food-secure	1	1	1
Mildly food-insecure	1.67 (1.27, 2.21)***	1.57 (1.19, 2.08)**	1.26 (0.95, 1.69)
Moderately food-insecure	1.72 (1.39, 2.12)***	1.44 (1.12, 1.85)**	1.11 (0.86, 1.44)
Severely food-insecure	2.36 (1.91, 2.91)***	1.88 (1.40, 2.38)***	1.36 (1.05, 1.76)**
Ethiopia			
Food-secure	1	1	1
Mildly food-insecure	1.18 (0.92, 1.50)	1.14 (0.89, 1.47)	1.13 (0.88, 1.45)
Moderately food-insecure	1.38 (1.13, 1.69)**	1.40 (1.15, 1.69)***	1.37 (1.14, 1.65)***
Severely food-insecure	1.58 (1.23, 2.04)***	1.58 (1.17, 2.12)**	1.48 (1.09, 2.00)*
Vietnam			
Food-secure	1	1	1
Mildly food-insecure	1.44 (1.14, 1.84)**	1.31 (1.05, 1.64)**	1.19 (0.95, 1.49)
Moderately food-insecure	1.85 (1.47, 2.31)***	1.57 (1.29, 1.91)***	1.39 (1.16, 1.65)***
Severely food-insecure	1.65 (1.17, 2.33)**	1.37 (0.99, 1.90)*	1.18 (0.85, 1.64)
Underweight			
Bangladesh			
Food-secure	1	1	1
Mildly food-insecure	1.50 (1.14, 197)**	1.37 (1.04, 1.82)	1.17 (0.88, 1.56)
Moderately food-insecure	1.42 (1.15, 1.75)**	1.17 (0.91, 1.50)	0.98 (0.76, 1.25)
Severely food-insecure	2.01 (1.64, 2.47)***	1.63 (1.28, 2.07)***	1.28 (0.99, 1.65)*
Ethiopia			
Food-secure	1	1	1
Mildly food-insecure	1.34 (1.02, 1.77)**	1.28 (0.96, 1.71)	1.23 (0.92, 1.64)
Moderately food-insecure	1.39 (1.11, 1.74)**	1.36 (1.08, 1.73)**	1.28 (0.99, 1.64)*
Severely food-insecure	1.90 (1.45, 2.50)***	1.85 (1.32, 2.59)***	1.68 (1.22, 2.30)***
Vietnam			
Food-secure	1	1	1
Mildly food-insecure	1.79 (1.38, 2.33)***	1.68 (1.28, 2.20)***	1.53 (1.14, 2.06)***
Moderately food-insecure	2.14 (1.67, 2.74)***	1.92 (1.49, 2.46)***	1.69 (1.28, 2.23)***
Severely food-insecure	1.78 (1.21, 2.61)**	1.50 (1.09, 2.08)***	1.28 (0.91, 1.79)
Wasting			
Bangladesh			
Food-secure	1	1	1
Mildly food-insecure	1.19 (0.84, 1.68)	1.12 (0.80, 1.57)	1.11 (0.79, 1.54)
Moderately food-insecure	1.07 (0.82, 1.40)	0.96 (0.74, 1.25)	0.95 (0.72, 1.24)
Severely food-insecure	1.58 (1.24, 2.01)***	1.38 (1.06, 1.79)*	1.34 (1.02, 1.75)*
Ethiopia			
Food-secure	1	1	1
Mildly food-insecure	1.21 (0.73, 2.01)	1.12 (0.61, 2.06)	1.06 (0.58, 1.93)
Moderately food-insecure	1.13 (0.73, 1.73)	1.06 (0.70, 1.60)	0.96 (0.62, 1.49)
Severely food-insecure	1.22 (0.72, 2.06)	1.18 (0.65, 2.13)	1.06 (0.58, 1.93)
Vietnam			
Food-secure	1	1	1
Mildly food-insecure	1.03 (0.64, 1.66)	1 (0.61, 1.65)	0.91 (0.54, 1.54)
Moderately food-insecure	1.64 (1.10, 2.45)*	1.56 (1.10, 2.21)**	1.38 (0.93, 2.05)
Severely food-insecure	1.3 (0.68, 2.49)	1.24 (0.62, 2.45)	1.05 (0.50, 2.19)

[1] Values are ORs (95% CIs). $*P < 0.05$, $**P < 0.01$, $***P < 0.001$. HFI, household food insecurity.
[2] Bivariate model showing association between HFI and undernutrition before adjusting for other covariates.
[3] Model adjusted for household size, maternal age, maternal education, maternal height (only for stunting), child age, child sex, acute respiratory illness, and diarrhea.
[4] Full model: adjusted for all variables in model 3 plus wealth index.

nutritional status. In addition, there might be other pathways by which HFI affects nutrition, including through other caregiving and feeding practices (e.g., quantity and not only quality of diet) and factors such as maternal depression, which have been found to be associated with both HFI and child nutrition and morbidity in these 3 countries (28). Alternatively, child DD may not have accurately reflected micronutrient adequacy of the diet in these populations, although the indicator has been validated and shown to be a good predictor of micronutrient adequacy in infants and young children (29).

We explored whether the effect of HFI on child undernutrition was independent of a household's wealth status by conducting models with and without the household wealth index. We found that, although the wealth index attenuated the effect size for the associations between HFI and undernutrition (stunting and underweight in all 3 countries and wasting in Bangladesh), HFI remained significant in models from all 3 countries. The wealth index also maintained its statistical significance in models that included HFI, suggesting that the effects of HFI and wealth on child undernutrition are, at least partly, independent (not shown in Table 4) (30,31). Previous studies (10–12,24) exploring a similar association considered household economic status as an independent variable in the model, confirming our assumption that the wealth index exerts an effect on undernutrition through additional pathways other than simply through HFI.

Seasonality is another important factor that may affect HFI as well as undernutrition, particularly wasting and underweight, and illness prevalence. The strength of the association between HFI and wasting or underweight may also change with seasonal variations. Our cross-sectional study, however, could not capture these potential variations in the associations between HFI and undernutrition due to seasonal effects within countries. We recognize that this seasonal dimension, however, may affect the comparisons in HFI and undernutrition and illness prevalence across the 3 countries. For example, in Bangladesh, data were collected after harvest, a period of plenty; whereas in Ethiopia the survey coincided with the long rainy season, when there is generally a lack of food at home.

In our sample, the prevalence of HFI in Bangladesh was much lower (32%) than the prevalence (60%) reported in the Food Security and Nutrition Surveillance Project (FSNSP) conducted in the same year (32) but during a different season. The FSNSP was carried out in October–November during the preharvest season, which is considered a period of severe food insecurity for rural people in Bangladesh due to lack of food and low employment opportunities in agriculture. Differences in the prevalence of HFI between the 2 surveys may also be due to differences in geographic areas sampled. The FSNSP survey was conducted in 38 districts from 6 food-insecure zones. Only 60% of the sample in the present study belonged to those food-insecure zones.

The prevalence of HFI reported in another study from Ethiopia was higher than the prevalence that we found in our study. Approximately 82% of households in Sidama districts in southern Ethiopia faced mild to severe food insecurity as per similar measures of HFI (33). Severe HFI was 48% in that study compared with only 15% in ours, with differences mainly due to reporting of severe food-insecurity experiences. Overreporting of severe items, perhaps because of expectation of food aid, could be an issue, as reported in the Sidama studies as well as in other studies (8). Another longitudinal study on chronic food insecurity in southwest Ethiopia over a 3-y period showed an increase in HFI, with 35% of households being chronically food-insecure across survey rounds (34).

In Vietnam, HFI was assessed in earlier studies by using different measures, such as calorie intake and DD (35,36); but, to our knowledge, our study is the first to explore food insecurity in Vietnam using the HFIAS.

One limitation of this study is that the associations between the HFI and undernutrition were examined by using cross-sectional data, in which HFI and child anthropometric characteristics were measured simultaneously. Stunting is a measure of chronic undernutrition resulting from prolonged hunger or food deprivation. In our study, HFI was measured on the basis of questions related to experiences in the 30 d before the survey and therefore reflects perceptions of short-term hunger and food insecurity. Thus, HFI estimated from a single survey round cannot differentiate between those who have been food-insecure for longer periods of time and those who experienced short-term, recent food insecurity.

In conclusion, results from this study suggest that interventions aimed at improving child undernutrition need to address food insecurity of their targeted population to maximize their potential nutritional impacts. Our unexpected finding of a lack of a mediating influence of child DD on the pathway between HFI and undernutrition intensifies the need to explore the role of children's dietary quantity and quality as well as other potential mediators such as child illnesses or maternal depression through further research.

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Literature Cited

1. Sen B, Hulme D. Chronic poverty in Bangladesh: tales of ascent, descent, marginality and persistence. Dhaka (Bangladesh): Bangladesh Institute of Development Studies, and Manchester (UK): Chronic Poverty Research Centre (CPRC), Institute for Development Policy and Management, University of Manchester; 2004.
2. World Food Programme. FAO/WFP crop and food security assessment mission to Ethiopia. Rome: Food and Agriculture Organization of the United Nations, World Food Programme; 2012 [cited 2012 Jul 26]. Available from: http://www.wfp.org/foodsecurity/reports/CFSAM.
3. Food Security Portal. Vietnam. 2012 [cited 2012 Jul 26]. Available from: http://www.foodsecurityportal.org/vietnam/resources.
4. UNICEF. The state of the world's children. New York: Oxford University Press; 1998 [cited 2010 Oct 30]. Available from: http://www.unicef.org/sowc98/pdf.htm.
5. Casey PH, Szeto K, Lensing S, Bogle M, Weber J. Children in food-insufficient, low-income families: prevalence, health, and nutrition status. Arch Pediatr Adolesc Med. 2001;155:508–14.
6. Matheson DM, Varady J, Varady A, Killen JD. Household food security and nutritional status of Hispanic children in the fifth grade. Am J Clin Nutr. 2002;76:210–7.
7. Rose D. Economic determinants and dietary consequences of food insecurity in the United States. J Nutr. 1999;129:517S–20S.
8. Coates J, Swindale A, Bilinsky P. Household Food Insecurity Access Scale (HFIAS) for measurement of household food access: indicator guide. Version 3. Washington: Food and Nutrition Technical Assistance Project, Academy for Educational Development; 2007.
9. Bickel G, Nord M, Price C, Hamilton W, Cook J. Guide to measuring household food security: revised 2000. Alexandria (VA): US Department of Agriculture, Food and Nutrition Service; 2000.
10. Baig-Ansari N, Rahbar MH, Bhutta ZA, Badruddin SH. Child's gender and household food insecurity are associated with stunting among

young Pakistani children residing in urban squatter settlements. Food Nutr Bull. 2006;27:114–27.

11. Hackett M, Melgar-Quiñonez H, Alvarez M. Household food insecurity associated with stunting and underweight among preschool children in Antioquia, Colombia. Rev Panam Salud Publica. 2009;25:506–10.
12. Osei A, Pandey P, Spiro D, Nielson J, Shrestha R, Talukder Z, Quinn V, Haselow N. Household food insecurity and nutritional status of children aged 6 to 23 months in Kailali District of Nepal. Food Nutr Bull. 2010;4:483–94.
13. Saha KK, Frongillo EA, Alam DS, Arifeen SE, Persson LA, Rasmussen KM. Household food security is associated with infant feeding practices in rural Bangladesh. J Nutr. 2008;138:1383–90.
14. Saha K, Bamezai A, Khaled A, Subandoro A, Rawat R, Menon P. Alive & Thrive baseline survey report: Bangladesh. Washington: International Food Policy Research Institute; August 2011 [cited 2013 May 6]. Available from: http://www.aliveandthrive.org/sites/default/files/AT_Bangladesh_FINAL%20Baseline_Report_April%2012%202012jv.pdf.
15. Ali D, Tedla M, Subandoro A, Bamezai A, Rawat R, Menon P. Alive & Thrive baseline survey report: Ethiopia. Washington: International Food Policy Research Institute; August 2011 [cited 2013 May 6]. Available from: http://www.aliveandthrive.org/sites/default/files/AT_Ethiopia_Baseline_FINAL_Report%20Mar%2028%202012%20JV.pdf.
16. Nguyen P, Manohar S, Tran ML, Subandoro A, Rawat R, Menon P. Alive & Thrive baseline survey report: Viet Nam. Washington: International Food Policy Research Institute; July 2011 [cited 2013 May 6]. Available from: http://www.aliveandthrive.org/sites/default/files/AT_Viet_Nam_FINAL%20Baseline_Report_Mar29_2012.pdf.
17. Cogill B. Anthropometric indicators measurement guide. Washington: Food and Nutrition Technical Assistance Project, Academy for Educational Development; 2003.
18. WHO. The WHO child growth standards. 2010 [cited 2012 Jan 22]. Available from: http://www.who.int/childgrowth/standards/en/.
19. WHO. Indicators for assessing infant and young child feeding practices. Part 2: measurement. Geneva: World Health Organization; 2010.
20. Filmer D, Pritchett LH. Estimating wealth effects without expenditure data–or tears: an application to educational enrollments in states of India. Demography. 2001;38:115–32.
21. Shea O. The DHS wealth index: approaches for rural and urban areas. Demographic and Health Research Division, Macro International; 2008 [cited 2012 Jan 30]. Available from: http://www.measuredhs.com/pubs/pdf/WP60/WP60.pdf.
22. Vyas S, Kumaranayake L. Constructing socio-economic status indices: how to use principal components analysis. Health Policy Plan. 2006;21:459–68.
23. StataCorp. STATA statistical software: release 12. Quick reference and index. College Station (TX): StataCorp LP; 2011.
24. Saha KK, Frongillo EA, Alam DS, Arifeen SE, Persson LA, Rasmussen KM. Household food security is associated with growth of infants and young children in rural Bangladesh. Public Health Nutr. 2009;12:1556–62.
25. Arimond M, Ruel MT. Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys. J Nutr. 2004;134:2579–85.
26. Menon P, Bamezai A, Subandoro A, Ayoya MA, Aguayo V. Age-appropriate infant and young child feeding practices are associated with child nutrition in India: insights from nationally representative data. Matern Child Nutr. Epub 2013 Apr 5; DOI:10.1111/mcn.12036.
27. Zongrone A, Winskell K, Menon P. Infant and young child feeding practices and child undernutrition in Bangladesh: insights from nationally representative data. Public Health Nutr. 2012;15:1697–704.
28. Nguyen PH, Saha KK, Ali D, Menon P, Manohar S, Mai LT, Rawat R, Ruel MT. Maternal mental health is associated with child undernutrition and illness in Bangladesh, Vietnam and Ethiopia. Public Health Nutr. Epub 2013 May 3:1–10.
29. Working Group on Infant and Young Child Feeding Indicators. Developing and validating simple indicators of dietary quality and energy intake of infants and young children in developing countries: summary of findings from analysis of 10 data sets. Washington: Food and Nutrition Technical Assistance (FANTA) Project, Academy for Educational Development (AED); 2006.
30. Mohsena M, Mascie-Taylor CG, Goto R. Association between socio-economic status and childhood undernutrition in Bangladesh; a comparison of possession score and poverty index. Public Health Nutr. 2010;13:1498–504.
31. Rahman A, Chowdhury S. Determinants of chronic malnutrition among preschool children in Bangladesh. J Biosoc Sci. 2007;39:161–73.
32. Helen Keller International. The Food Security and Nutrition Surveillance Project round 3: Bangladesh. Dhaka (Bangladesh): Helen Keller International; 2010.
33. Regassa N, Stoecker BJ. Household food insecurity and hunger among households in Sidama district, southern Ethiopia. Public Health Nutr. 2012;15:1276–83.
34. Belachew T, Lindstrom D, Gebremariam A, Jira C, Hattori MK, Lachat C, Huybregts L, Kolsteren P. Predictors of chronic food insecurity among adolescents in Southwest Ethiopia: a longitudinal study. BMC Public Health. 2012;12:604.
35. Gill G, Farrington J, Anderson E, Luttrell C, Conway T, Saxena N, Slater R. Food security and the Millennium Development Goal on hunger in Asia. London: Overseas Development Institute; 2003.
36. Molini V. Food security in Vietnam during the 1990s: the empirical evidence. Helsinki (Finland): UNU-WIDER; 2006.