

Household food insecurity and nutritional status in children: Results from an eight-country study

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ABSTRACT

Background: Stunting results from decreased food availability and a high burden of early infections, and contributes to significant morbidity and mortality worldwide. While food insecurity is an important determinant of child nutrition, development of a cross-country measure has been challenging due to cumbersome nutritional questionnaires and concerns about lack of comparability across countries. We investigate the relationship between food insecurity and indicators of nutritional status in early childhood.

Methods: We administered a socioeconomic survey to 800 households in eight countries, including a recently validated nine-item food security questionnaire, and obtained anthropometric measurements in children aged 24 to 60 months. We used multivariable regression approaches to assess the relationship between household food insecurity and indicators of nutritional status in children.

Results: The average age of study children was 41 months. Overall mean food insecurity score (ranging from 9 to 36) was 30.2, ranging from 27.7 in Pakistan to 33.6 in Nepal. Across countries, the prevalence of stunting (42%) was much higher than the prevalence of wasting (6%). In pooled regression analyses, a 10-point decrease in food security score was associated with a 0.23 SD decrease in height-for-age (95% CI 0.09 to 0.37 SD). A test for heterogeneity revealed that this relationship was consistent across countries ($p=0.17$).

Conclusions: Our study provides evidence of the validity of using a simple household food security score to investigate factors involved in the etiology of childhood malnutrition across diverse cultural settings. Such measures could be used to identify children at risk of illness and death due to growth faltering and target interventions accordingly.

BACKGROUND

One in every five children in the developing world is malnourished, and poor nutrition is linked to more than half of all child deaths worldwide (Black et al. 2008; Caulfield et al. 2004). Malnutrition in early childhood may lead to cognitive and physical deficits and may cause similar deficits in future generations as malnourished mothers give birth to low birth weight infants (Victora 2008).

Malnutrition also increases susceptibility and incidence of infections and is associated with diminished response to vaccines. The root of malnutrition in early childhood is complex with a variety of direct and underlying contributors related to lack of food, including insufficient breastfeeding and inadequate complementary foods; protein and nutrient loss from multiple respiratory and gastrointestinal infections; chronic immune stimulation due to persistent parasitic intestinal infections; and inadequate water and sanitation (Campbell et al. 2003; Checkley et al. 2004).

Food insecurity is a key risk factor for malnutrition. Based on the 1996 World Food Summit, food security occurs “when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life” (World Health Organization). Food security comprises three main components: availability, access and utilization (Sen 1981). Availability is often measured through proxies at the population level, such as national agricultural output, while access and utilization are more often measured at the household and individual levels. Approaches to measuring access and utilization have ranged from the use of children’s nutritional status (Barrett et al. 2010), to more direct methods such as food frequency questionnaires (Carlsen 2010).

Measurement of food insecurity using surveys has posed persistent challenges, such as the high cost and time requirements of collecting accurate individual level data on food consumption. Recent research, however, shows promise in the construction of simple household survey measures

such as the Household Food Insecurity Access Scale (Webb et al. 2006; Barrett et al. 2010; Coates et al. 2006). Low-cost and valid measures of food insecurity are necessary to accurately estimate global burden and predict the prevalence of food insecurity in response to changing conditions (Hadley et al. 2009). Better measurement of food insecurity can inform targeted interventions to prevent outcomes such as childhood morbidity and mortality. However, global progress against food insecurity requires measures that are valid and comparable across countries. We sought to assess the validity of an existing nine-item measure of household food security in the setting of a multi-country study. To achieve this aim, we collected cross-sectional data on household food insecurity and child nutritional status as measured by anthropometry in eight countries to determine whether these variables were related, and whether this relationship was consistent across countries.

MATERIALS AND METHODS

Study setting

We conducted our study at the eight field sites in the Malnutrition and Enteric Infections: Consequences for Child Health and Development (MAL-ED) Network cohort study. The MAL-ED Network, comprising researchers from thirteen academic and research institutions, aims to explore the relationship between malnutrition and intestinal infections and their consequences for various aspects of child growth and development. We developed a standardized protocol for the collection of twice weekly surveillance, monthly anthropometry, urine for gut function, stool for enteric pathogens, blood for micronutrients and vaccine response, and cognitive development assessments. Study sites are located in Bangladesh, Brazil, India, Nepal, Pakistan, Peru, South Africa and Tanzania. We began enrolling pregnant women in 2009, and plan to follow approximately 200 newborns per site for up to 36 months.

Study Design

In preparation for the main cohort study, we sought to develop cross-country indicators of socioeconomic status and food insecurity. We administered a survey including demographic, socioeconomic status, and food insecurity questions to a random selection of 100 households in each of the eight field sites between September 2009 and August 2010. Households were eligible to participate if they were located within the MAL-ED study area and if they had an index child aged 24 to 60 months. We obtained ethical approval from the Institutional Review Boards at each of the participating research sites, at the Bloomberg School of Public Health of Johns Hopkins University (Baltimore, USA) and at the School of Medicine of the University of Virginia (Charlottesville, USA).

We used a single, standardized socio-demographic and food security survey at all sites. Demographic and socioeconomic status questions were adapted from the most recent Demographic and Health Surveys in collaboration with all investigators. These questions focused on age, education, and fertility history for the head of household and mother of the measured child. Socioeconomic status included a series of questions on household assets, housing materials, water source and sanitation facilities. The questionnaire was developed in English then translated into local languages by site investigators. Mothers or primary caretakers were asked the ages of each child. Prior to survey administration, training sessions were held and attended by field workers responsible for data collection. Field supervisors used locally appropriate management techniques to support complete, accurate and timely data collection, and reviewed all data weekly to ensure quality.

Food security score

To assess food insecurity, our survey included the nine question Household Food Insecurity Access Scale (Table 1), adapted in 2006 by the Food And Nutrition Technical Assistance project for use in low resource settings (Swindale et al. 2006). While this scale has been validated and adapted in individual country settings, it has not been used in its original form in a multi-country study (Swindale et al. 2006; Frongillo et al. 2006; Melgar-Quinonez et al. 2006). The nine-item scale uses a four-week recall period and was constructed to capture three larger dimensions of household food insecurity: anxiety and uncertainty about household food access (item 1); insufficient quality (items 2-4); and, insufficient food intake and its physical consequences, or hunger (items 5-9) (Swindale et al. 2006). Responses on the nine items were summed to create the food security score, with a maximum score of 36 indicating the most food secure households, and a minimum score of 9 indicating the most food insecure households.

Anthropometry

We measured one child aged 24 to 60 months for height and weight in each participating household. Trained field staff measured standing height to the nearest 0.1 cm using a locally produced platform with sliding headboard. Digital scales were used to measure weight to the nearest 100 grams. Height-for-age (HAZ) and weight-for-height (WHZ) Z-scores were calculated based on World Health Organization child growth standards (World Health Organization, online). We defined stunting and wasting as a HAZ and WHZ that were two standard deviations below the mean, respectively.

Biostatistical methods

We used linear regression to model the relationship between food insecurity and each nutritional indicator, adjusted for age, sex, maternal education, if the household had a bank account, number of rooms per person in the household, and access to improved water and sanitation. To test for heterogeneity in the relationship between food insecurity and nutritional indicators across countries, we tested an interaction between the food security score and indicator variables for countries using a likelihood ratio test. We used R (www.r-project.org) and STATA 10 (Stata Corp., Texas Station, USA) for statistical analysis.

RESULTS

Baseline characteristics of study populations

We surveyed a total of 800 households. One child had missing anthropometry, and ten had extreme anthropometric values based on WHO standards. This resulted in a final sample size of 789 households (98.6% of original sample). The mean age of sampled children was 41 months. 51.5% of children were male, ranging from 58.6% in Tanzania to 44.3% in Pakistan.

We present summary measures of selected indicators of household socioeconomic status in Table 2. Variation in household socioeconomic status across countries is evidenced by the range of observed values for these items, such as maternal education and proportion with a bank account. In contrast, nearly all households reported access to improved water and sanitation and electricity, with the exception of Tanzania. On average, households in Tanzania and India appear to have the lowest socioeconomic status, while households in South Africa, Nepal, and Brazil appear to have the highest.

Household food security scores

Country-specific distributions of food security scores are displayed in Figure 1. Food security score distributions were highly skewed left, indicating a large subgroup of households reporting no food insecure experiences in the preceding four weeks. Across countries, 37% of all households reported no food insecurity in the last four weeks (score of 36). Between countries, this value ranged from 18% to 72% of households. Nepal (33.6) and Tanzania (33.4) had the highest mean scores, as well as the smallest variability between households ($SD=4.8$ for both), while Pakistan (27.7) and Brazil (28.1) had the lowest mean scores. Brazil had the largest variability ($SD=7.8$).

Nutritional indicators

Figures 2 and 3 display country-specific distributions of child HAZ and WHZ, respectively. Overall, 39% (range from 85% to 55%) of children were stunted, and 6% (range from 0% to 16%) were wasted. India and Brazil's HAZ distributions are shifted toward the highest values, with approximately 35% of Brazilian children and 30% of Indian children measuring above the median. In the remaining six sites, approximately 50% of each population is stunted, as in Bangladesh, where the entire sample falls below the global median height for age. On average, a much smaller proportion of children are experiencing growth faltering in terms of weight for height. In both South Africa and Tanzania, where over 50% of the sample children are stunted, none of them are wasted. In contrast, in India, where about 22% of children are stunted (fewer than most sites), a similar proportion (17%) is wasted (more than most sites).

Table 3 displays associations between socio-demographic indicators and stunting, wasting, and low food security (defined as less than the sample median of 32). Stunting is statistically significantly associated with age, water source, sanitation source, mother's education, and people per room. Wasting is associated with water source and people per room. Low food security is significantly associated with sex, mother's education, ownership of a bank account, and people per room. Both wasting and stunting appear related to water and sanitation sources. Wasting and stunting were weakly correlated ($r = -0.02$; $p < 0.0001$).

Association between food security and nutritional indicators

In exploratory analysis, the relationship between food security and HAZ appeared approximately linear (Figure 4). Across all countries, food security score was significantly associated with HAZ ($p < 0.01$), but not with WHZ (Table 4). In pooled regression analyses, a 10-point decrease in food

security score was associated with a 0.23 SD decrease in height-for-age (95% CI 0.09 to 0.37 SD), controlling for water source and maternal education. The relationship between food security score and HAZ score did not vary significantly across countries ($p=0.17$).

DISCUSSION

In this study, we found that food insecurity was significantly associated with a shift in the distribution of height for age toward lower values. In pooled regression analyses, a 10-point decrease in food security score (ranging from 9 to 36) was associated with a 0.23 SD decrease in height-for-age (95% CI 0.09 to 0.37 SD). Although prevalence of both food security and HAZ varied across countries, our test for heterogeneity revealed that the relationship between these variables was consistent. Using household socio-demographic data, child anthropometry, and a nine-item food security score, we were able to investigate the relationships between these variables.

Patterns in socioeconomic status, food security, and growth faltering were not clearly clustered by region, and no country ranked consistently highest or lowest in all factors. For example, on average Tanzanian households were among the poorest when measured by asset indicators, but were also among the most food secure. The opposite pattern was true of Brazilian households, which also had among the highest mean HAZ and WHZ. The complexity of these relationships further underlines the utility of a simple measure, such as household food insecurity, that could potentially predict growth faltering in children.

The prevalence, correlates, and correlation between measures of growth faltering in this sample are consistent with the literature. Previous studies have reported higher levels of stunting than wasting within populations (Olusanya et al. 2010; Singh et al. 2006), and more variation in wasting than stunting across populations (Black et al. 2008; Victora et al. 1992). In contrast to our results, some research has found clear regional patterns in prevalence of stunting and wasting (Victora et al. 1992; Black et al. 2008; Olusanya et al. 2010). Variations between sites might reflect the impact of numerous factors, including seasonal effects on the food supply, patterns of enteric infections, genetic predispositions, and access to prenatal and infant health services.

Stunting and wasting are indicators of chronic and acute malnutrition, respectively. However, beyond reflecting differences in the length of exposure to deprivation, they are also differentially associated with other socio-demographic variables, such as mother's education and immunizations (Frongillo et al. 1997; Olusanya et al. 2010). Given the different risk factors for wasting and stunting, and the weak correlation between these measures in our data, it is not surprising that food security is associated with faltering in height-for-age but not weight-for-height. In addition to different risk factors, growth faltering in weight for height tends to occur at younger ages and result in higher mortality than faltering in height for age (Black et al. 2008). Given the age of children enrolled in this study (older than 24 months), they were more likely to be stunted or healthy than to be wasted. Finally, our results indicate that food security is not simply an indicator of SES, but is independently associated with growth faltering after controlling for measures of SES.

The Food And Nutrition Technical Assistance project has worked since 2000 to validate and adapt this scale (Swindale et al. 2006). More recent (unpublished) validation work in a cross-country setting has produced mixed results, leading investigators to suggest a shortened version of the scale comprising only the final three items (Deitchler et al. 2010). Using the adapted version of the scale produces similar results in our data, although the shorter version only includes items related to hunger. The full scale is more desirable than the reduced scale for two reasons. First, more items generally results in higher scale reliability (Carmines & Zeller, 1979). Second, since we seek to measure a broader experience of food security beyond hunger, the original scale, capturing uncertainty, quality, and hunger, is more relevant in this setting.

These results also provide evidence of the acceptability and validity of the nine-question Household Food Insecurity Access Scale in a multi-country research setting. We were able to use the questions in their original form (with translation) in diverse cultural settings with limited problems in

administration and no missing data. Our results, demonstrating a statistically significant relationship between food security and height-for-age, two variables that we would expect to be correlated, provide evidence of construct validity of the scale in a multi-country setting (Cronbach & Meehl, 1955). Furthermore, while this measure only focuses on the access aspect of food security, previous research has indicated that it correlates with dietary quality and the intake of a micronutrient rich diet, two aspects of food utilization (Melgar-Quinonez, 2006). Finally, the lack of heterogeneity in this relationship across countries provides evidence of generalizability of its use to diverse low-income settings. The MAL-ED cohort study will allow us to look at food utilization – and its relationship with food access – more closely through inclusion of food frequency questionnaires.

Our study has some limitations. The data are cross-sectional, preventing the collection of important longitudinal risk factors for malnutrition, such as intestinal infections. However, the statistically significant association between food security and HAZ indicates the utility of the former measure in settings where other data are not available. Our study included children aged 24-60 months, although wasting effects are often greatest in the first two years of life (Black et al. 2008). The MAL-ED cohort study will follow children from birth, collecting data on diarrheal incidence and infectious agents, seasonal changes in food security, and other important exposures, such as micronutrient intake. Another limitation is that we did not have estimates of the variability of food security score with which to properly power the study. It is possible, although unlikely given our results, that with a larger sample size we might have found significant associations between food security and WHZ. In addition, some MAL-ED sites raised concerns that responses to certain food security items might be culturally dependent. While further inquiry is warranted on cross-country variations in response thresholds, previous research does indicate that the domains of the food security experience are surprisingly similar across cultural settings (Coates et al. 2006). Finally,

factors affecting child growth are present not only at the household level but also at the community, national, and regional levels. Therefore, information provided through a household survey can only explain a limited amount of variation in child growth outcomes (Frongillo et al. 1997).

In summary, a simple food security score can help explain differences in height for age distributions in a multi-country study even after adjustment for demographics, socioeconomic status, and country-level differences. Given the simplicity of this measure of food security, and acceptability and validity in cross-country settings, we advocate its inclusion in research and programs seeking to understand and ameliorate the predictors of child malnutrition in developing countries.

Table 1. Household Food Insecurity Access Scale.

Each question has the following response categories: No (1), Rarely (2), Sometimes (3) Often (4).

In the past four weeks:

1	Did you worry that your household would not have enough food?
2	Were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?
3	Did you or any household member have to eat a limited variety of foods due to a lack of resources?
4	Did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?
5	Did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?
6	Did you or any other household member have to eat fewer meals in a day because there was not enough food?
7	Was there ever no food to eat of any kind in your household because of lack of resources to get food?
8	Did you or any household member go to sleep at night hungry because there was not enough food?
9	Did you or any household member go a whole day and night without eating anything because there was not enough food?

Table 2. Proportion of households reporting that they own an asset (n=787).

	All	BG	BR	IN	NE	PK	PE	SA	TZ
Sample size	789	99	98	100	100	98	99	96	99
Owens bank account (%)	31%	23%	21%	10%	62%	39%	15%	76%	2%
Rooms per person (mean)	0.6	0.4	1.0	0.3	0.6	0.2	0.7	1.2	0.7
Improved water (%)	86%	100%	100%	100%	98%	100%	98%	65%	28%
Improved sanitation (%)	73%	100%	100%	37%	100%	74%	84%	84%	1%
Maternal education (mean)	6.4	3.7	7.8	6.7	6.6	3.3	7.8	10.1	5.3
Owens Mattress (%)	58%	66%	98%	99%	99%	13%	82%	66%	39%
Owens mobile phone (%)	68%	62.6	80.6	53.0	96.0	68.4	31.3	95.8	53.5
Owens radio or transistor (%)	41%	11%	74%	2%	48%	12%	55%	82%	46%
Has electricity (%)	84%	100%	99%	97%	99%	98%	85%	94%	0%
Owens table (%)	57%	29%	86%	21%	65%	50%	100%	74%	33%

Table 3. Relationship between socioeconomic status and nutritional indicators.

	n	% Stunted	p †	% Wasted	p †	Low food security score (%) [§]	p †
Sex							
Male	406	42.1	0.95	6.7	0.50	44.1	<0.01
Female	382	41.9		5.5		53.7	
Age							
24-35 months	284	41.2	0.01	5.3	0.07	46.8	0.36
36-47 months	243	49.0		4.1		46.9	
48-60 months	262	36.3		8.8		52.3	
Water Source							
Not improved	109	58.7	<0.001	0.0	<0.01	42.2	0.15
Improved	680	39.3		7.1		49.7	
Sanitation Source							
Not improved	218	49.5	<0.01	6.4	0.81	50.0	0.65
Improved	571	39.1		6.0		48.2	
Maternal education							
None	135	57.0	<0.001	5.2	0.15	60.7	<0.001
1-5 years	174	43.1		9.1		54.6	
> 5 years	480	37.3		5.2		43.1	
Bank Account							
No	545	42.2	0.83	6.6	0.36	54.3	<0.001
Yes	244	41.4		4.9		36.1	
People per room							
< 2	356	50.0	<0.001	10.1	<0.001	58.1	<0.001
≥ 2	43	35.3		2.8		40.9	

[§]Low food security is defined for this data set as less than the median score of 32.

[†]p-values reflect results of two group t and one-way ANOVA (three group) tests.

Table 4. Final models exploring the relationship between food security score and two measures of growth faltering, controlling for covariates.

	HAZ		WHZ	
	Full model	Final model	Full model	Final model
Intercept	-2.909 (<0.0001)	-3.151 (<0.0001)	1.086 (0.001)	0.917 (0.297)
Food Security Score	0.022 (0.004)	0.023 (0.001)	-0.007 (0.323)	-0.007 (0.331)
Bangladesh	-0.189 (0.455)	-0.243 (0.246)	-1.106 (<0.0001)	-1.111 (0.157)
Brazil	1.578 (<0.0001)	1.554 (<0.0001)	0.629 (0.009)	0.616 (0.160)
Peru	0.162 (0.504)	0.151 (0.474)	0.312 (0.163)	0.280 (0.155)
India	0.397 (0.074)	0.362 (0.088)	-1.357 (<0.0001)	-1.432 (0.158)
Pakistan	-0.015 (0.952)	-0.067 (0.756)	-1.100 (<0.0001)	-1.145 (0.162)
Nepal	0.118 (0.641)	0.070 (0.734)	0.285 (0.222)	0.263 (0.153)
South Africa	-0.114 (0.640)	-0.132 (0.494)	0.975 (<0.0001)	0.944 (0.164)
Tanzania (ref)				
Age	-0.005 (0.247)		-0.011 (0.004)	-0.011 (0.004)
Sex	-0.039 (0.647)		-0.085 (0.274)	
Water [‡]	0.375 (0.032)	0.368 (0.034)	-0.146 (0.366)	
Toilet [‡]	-0.023 (0.871)		0.105 (0.423)	
Mother's education [§]	0.026 (0.033)	0.026 (0.029)	-0.002 (0.860)	
Bank account	-0.043 (0.699)		-0.027 (0.791)	
Rooms per person	0.056 (0.579)		-0.190 (0.040)	-0.188 (0.091)
Adjusted R ²	19.9%	20.2%	35.4%	35.4%

[‡]Dichotomous variables measuring access to improved facilities (water or toilet).¹

[§]Continuous measure of years of schooling.

Figure 1. Histograms Showing Food Security Scores by Country

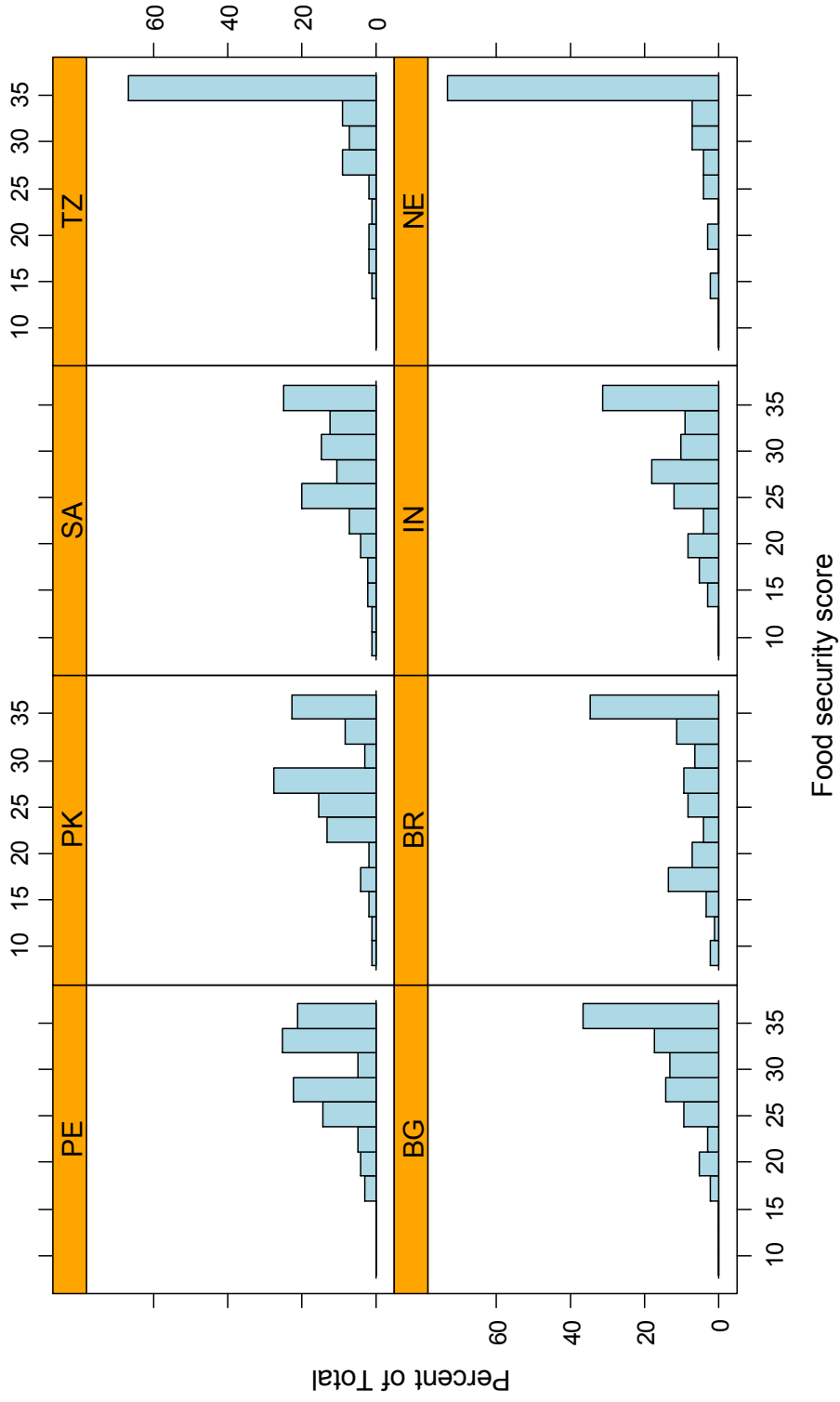


Figure 2. . . Box Percentile Plots of Height for Age Z Scores by Country

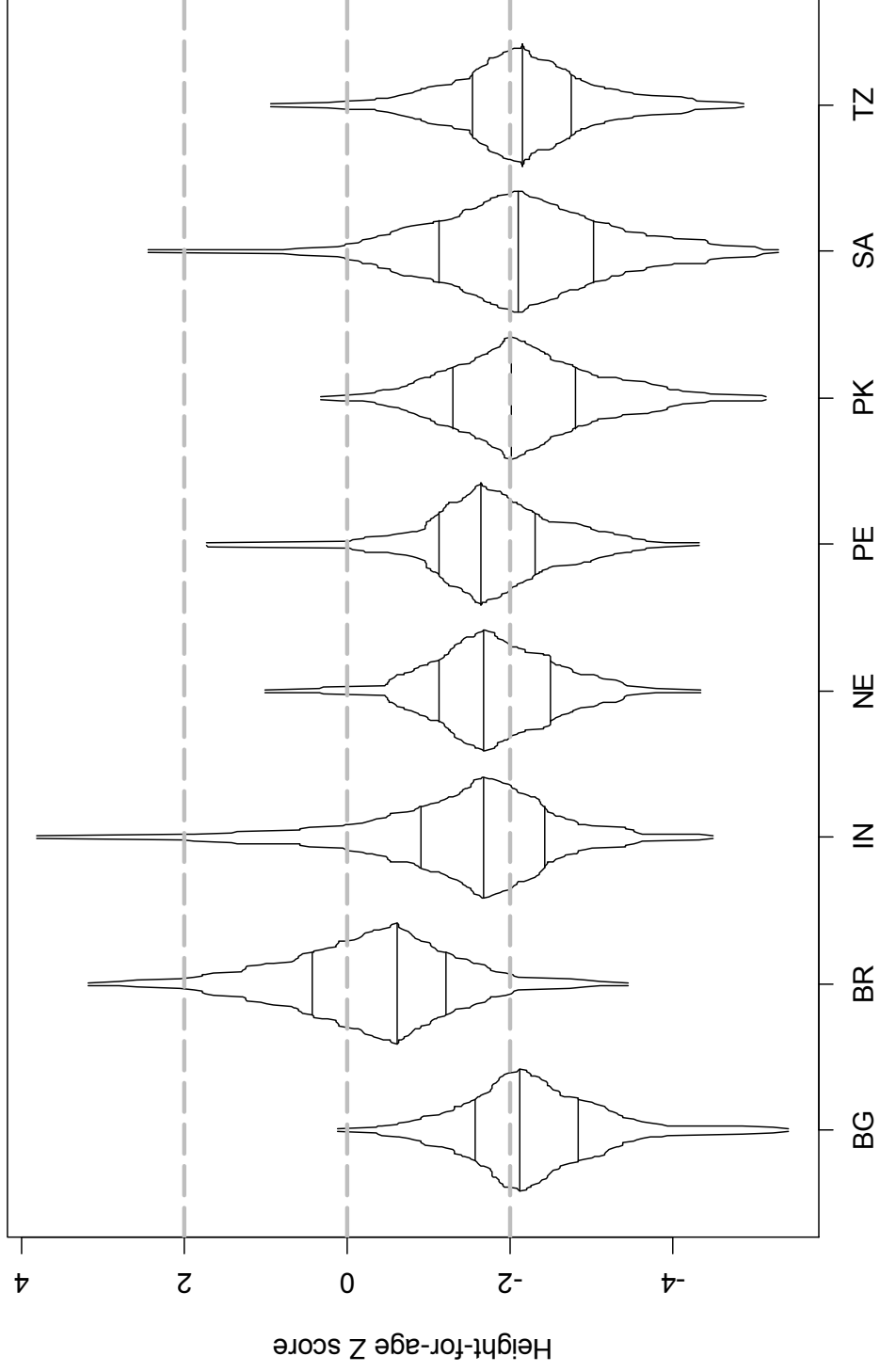


Figure 3. Box Percentile Plots of Weight for Height Z Scores by Country

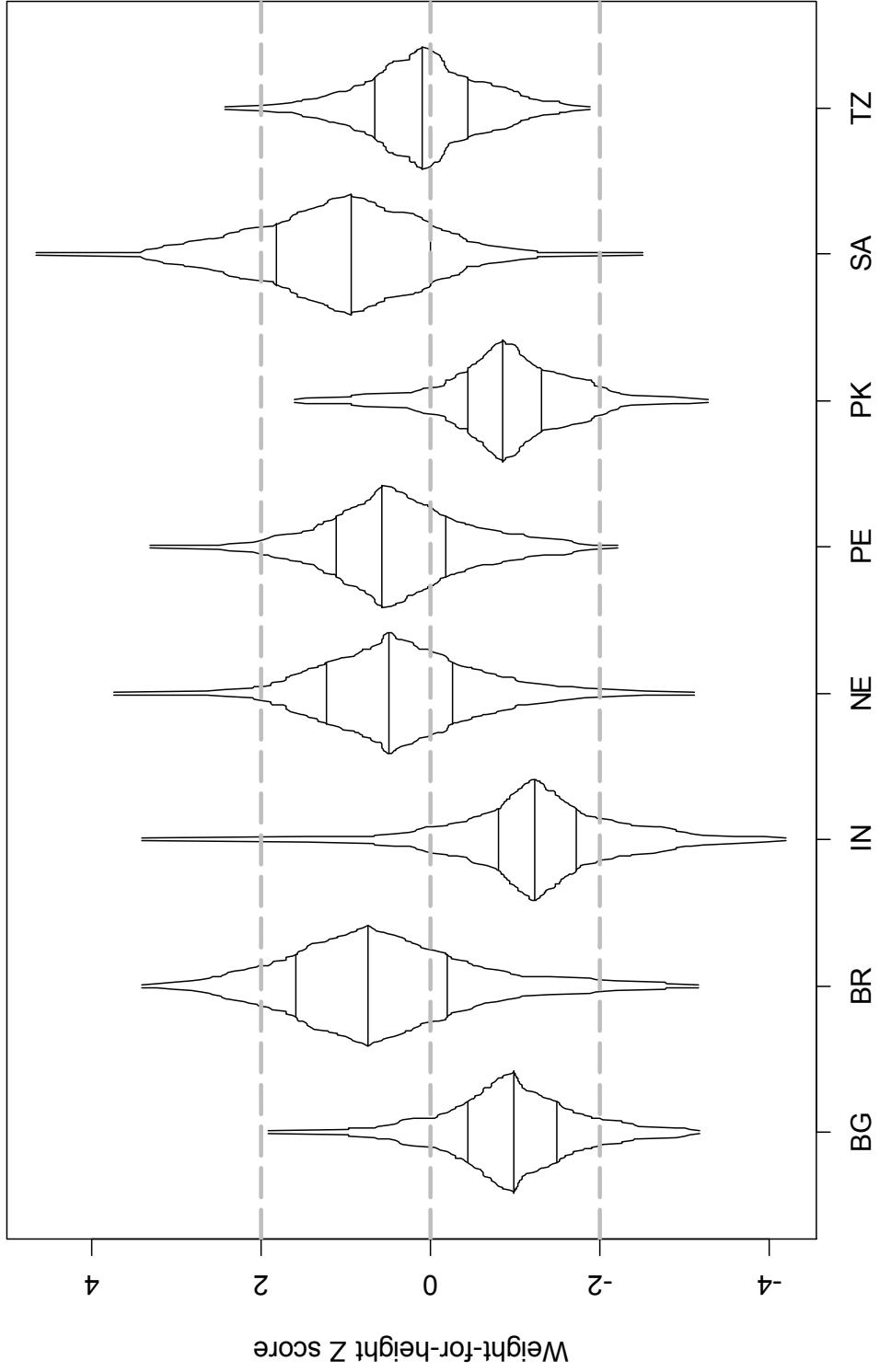
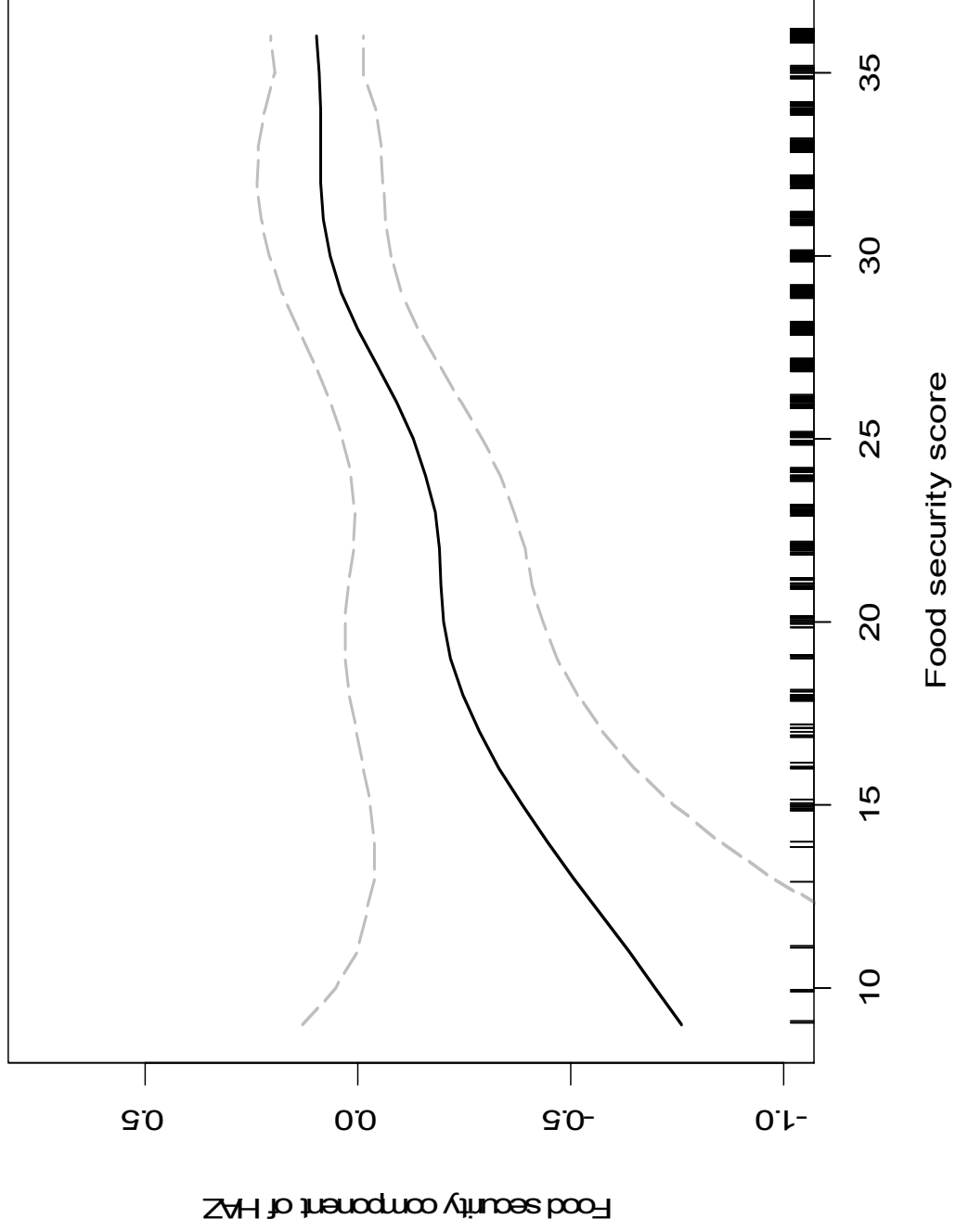


Figure 4. Fitted spline showing the linear relationship between food security score and HAZ



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