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Abstract
Globally, food insecurity is a significant contextual aspect of childhood. About 850 million people were undernourished worldwide during the period 2006 to 2008, including 129.6 million people, or 10 percent of the population, in China (FAO 2011:45-46). Implications of food insecurity for children's schooling in developing country contexts are poorly understood. Analyses of a survey of children from 100 villages in northwest China show that long-term undernourishment and food insecurity strike the poorest disproportionately, but not exclusively; long-term undernourishment matters for literacy via early achievement; and, after adjusting for socioeconomic status, long-term undernourishment, and prior achievement, food insecure children have significantly lower literacy scores.

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Poverty, Food Insecurity and Nutritional Deprivation in Rural China: Implications for Children's Literacy Achievement

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- Worldwide, food insecurity is a significant contextual dimension of childhood poverty.
- Implications of food insecurity for children's schooling in developing country contexts are poorly understood.
- Analyses of nutrition, food security and literacy among children in 100 villages in northwest China are performed.
- Long-term undernourishment and food insecurity strike the poorest disproportionately, but not exclusively.
- Long-term undernourishment matters for literacy via early achievement.
- Adjusting for socioeconomic status, long-term undernourishment, and prior achievement, food insecure children have significantly lower literacy scores.

Globally, food insecurity is a significant contextual aspect of childhood. About 850 million people were undernourished worldwide during the period 2006 to 2008, including 129.6 million people, or 10 percent of the population, in China (FAO 2011:45-46). Implications of food insecurity for children's schooling in developing country contexts are poorly understood. Analyses of a survey of children from 100 villages in northwest China show that long-term undernourishment and food insecurity strike the poorest disproportionately, but not exclusively; long-term undernourishment matters for literacy via early achievement; and, after adjusting for socioeconomic status, long-term undernourishment, and prior achievement, food insecure children have significantly lower literacy scores.

Poverty, Food Insecurity and Nutritional Deprivation in Rural China: Implications for Children's Literacy Achievement

1 Introduction

According to guidelines developed by an expert working group of the American Institute of Nutrition (Cook and Frank 2008, p. 193), food insecurity is defined as "Limited or uncertain availability of nutritionally adequate and safe foods, or limited or uncertain ability to acquire acceptable foods in socially acceptable ways.[i]" Evidence suggests that insecure access to nutritious food remains a significant global problem. According to the Food and Agriculture Organization's *State of Food Insecurity in the World* (2011:45-46), 850 million people were undernourished worldwide during the period 2006-2008, including 129.6 million people, or 10 percent of the national population, in China.

Food insecurity has been linked to a wide variety of adverse health and developmental outcomes in children and adults—both nutrition-related and non-nutrition related (Cook and Frank, 2008; American Dietetic Association 2010). Food insecurity is associated with higher prevalence of inadequate intake of key nutrients (Rose, Habicht, and Devaney, 1998; Casey, Szeto, Lensing, Bogle, and Weber, 2001; Lee and Frongillo, 2001; Adams, Grummer-Strawn, and Chavez, 2003), risk of overweight status in women and some girls (Olson, 1999; Alaimo, Olson, and Frongillo, 2001; Laitinen, Power, and Jarvelin, 2001; Townsend, Peerson, Love, Achterberg, and Murphy, 2001; Dinour et al., 2007; but see Gundersen et al., 2012 for insignificant effects of food insecurity on children's overweight status in the US), depressive symptoms in adolescents (Alaimo, Olson, and Frongillo, 2002),

poorer interpersonal relations, less self control, and non-cognitive skills impairments and general academic difficulties and social developmental delays in children (Kleinman et al., 1998; Murphy et al., 1998; Alaimo et al., 2001; Reid, 2000; Stormer and Harrison, 2003; Ashiabi, 2005; Howard 2011; Roustit, Harmelin, Grillo, Martin, and Chauvin, 2010; Howard, 2010). Results from a longitudinal study of welfare recipients in the United States show that household food insecurity is associated with poor physical and mental health of low-income black and white women (Siefert, Heflin, Corcoran, and Williams, 2004). Food insecurity is also associated with more behavioral problems (Olson, 1999; Slack and Yoo, 2005), poorer school performance (Olson, 1999; Alaimo et al., 2001; Dunifon and Kowaleski-Jones, 2003), and adverse health outcomes (Alaimo, Olson, Frongillo, and Briefel, 2001; Cook et al., 2004; Weinreb et al., 2002) in children. Data from the Early Child Longitudinal Study-Kindergarten Class show that reporting at least one indicator of food insecurity was significantly associated with impaired learning in mathematics from fall to spring of the kindergarten year (Winicki and Jemison, 2003) and with impaired learning in reading from kindergarten to third grade (Jyoti, Frongillo, and Jones, 2005). Belsky et al. (2010, p. 809) characterize "material hardship related to food"—food insecurity, food insufficiency, and hunger—as a "reliable correlate of cognitive, behavioral, and emotional problems among low income children," but note that many, though not all, of the disadvantages are explained by other features of household structure.

The knowledge that we have about the consequences of food insecurity for children's well-being is limited in a number of ways. Relatively few studies have employed longitudinal data (Winicki & Jemison 2003; Jyoti et al. 2005). Most utilize data from developed countries, and most employ a fairly limited set of educational measurements.

Focusing on the case of rural children in an impoverished province in western China, we address these limitations in this project. Our dataset includes household measures of food insecurity reported by mothers and measures of long-term nutrition status (measured anthropometry), as well as a purpose-designed literacy assessment administered to children. We combine these measures with detailed measures of socioeconomic status of households, a strategy that allows us a close look at links between food insecurity and poverty. Finally, we employ a longitudinal dataset that allows us to adjust for baseline school performance.

We begin with the descriptive task of establishing prevalence of food insecurity among children, and the relation of this issue to poverty and to measured anthropometry. Next, we address our main analytic question: whether food insecurity is linked to children's learning outcomes, measured by a literacy assessment, before and after adjusting for baseline school performance and long term nutrition (captured by anthropometry measures).

2 Food Insecurity, Undernutrition, and Education in China

Undernutrition persists as a problem in parts of rural western China. The prevalence of child stunting declined dramatically in China from 1992 onwards, but a significant divide separates Western and Eastern provinces and rural and urban areas. The ratio of the prevalence of stunting in rural and urban areas increased from 3.5 to 7.2 between 1992 and 2002 (Svedberg, 2006).

While inadequate nutrition remains a serious problem in China's poor rural households, studies of rural children's nutrition and schooling are few and largely

descriptive. Jamison et al. (1986) linked nutrition to school achievement used a data set of 3000 children from five different provinces in China. Jamison and his colleagues found that height-for-age, a measure of long-term nutritional status, predicted school performance, measured by grade-for-age; similar findings prevailed through the 1990s, as shown in a replication using the China Health and Nutrition Survey data (Yu and Hannum 2007). Using data from northwest China, Yu and Hannum (2007) found that home nutrition environment, measured as a scale of food variety, was associated with household socioeconomic status and children's school performance, and operated as a significant mediator of poverty effects on schooling for children in early primary grades. We are not aware of published work linking food insecurity to school performance in China.

3 Data and Methods

3.1 Data

This study focuses on data from rural children who are residents of Gansu Province. Relative to China as a whole, Gansu Province exhibits high rates of illiteracy and prevalent poverty. As one of China's poorest provinces, Gansu provides a useful case study for investigating food insecurity-education linkages in a less developed setting. We employ data from the Gansu Survey of Children and Families (GSCF). In the summer of 2000, 2,000 children aged 9-12 and their families in 100 rural villages in Gansu Province were interviewed. The sampling strategy involved a multi-stage, cluster design with random selection procedures employed at each stage. At the final stage, children were sampled from lists of all 9 to 12 year-old children in selected villages, enabling us to avoid concerns about selection bias that afflict school-based samples. Questionnaires were designed for

the sample children and their mothers, fathers, teachers, principals and village leaders. In 2004, original interviewees were revisited, as well as a new sample of oldest younger school-aged siblings.

3.2 Measures

We report results based on two measures of food insecurity. First, we employ a dichotomous measure, household food insecurity, which is based on mothers' responses to the following question: In the past year, which of the following statement describe best your family's food supply? The answer options are 1) often not having enough food; 2) Sometimes not having enough food; 3) Always having enough food. We defined a *food insecurity* dummy variable as "1" if the answers were 1) and 2), else 0. We show descriptives for this variable as reported by mothers in 2000 and 2004, but all analyses rely on the 2004 variable.

[TABLE 1. FOOD INSECURITY REPORTED BY MOTHERS OF TARGET CHILDREN, 2000 AND 2004]

We also report results using a different food insecurity specification: a scale variable that we refer to as the food insecurity severity index.[ii] Mothers who reported being food insecure were asked a series of six questions, shown in Table 1, about actions that might be undertaken to respond to food shortages in the preceding year. If they answered that each action had been taken, they were then asked about the frequency of the action. To create the scale, we generated six new variables—one for each of the six questions about the frequency with which each action had been taken. We set the frequency to 0 for food secure households and for households that reported not having taken the action specified in the original question. Other values for these questions were 1 "only in one or two

months;" 2 "in some months, but not every month;" or 3 "in almost every month". We then generated a summative scale of the standardized items (alpha=.7898).

Child's long-term nutritional status is indicated by measured weight and height at Wave II. Using the U.S. CDC 2000 growth reference, we calculated height- and weight-for-age Z scores, and defined "stunting" as having a less than -2 height-for-age z score and "severely underweight" as having a less than -2 weight-for-age Z score.

Our main analytic outcome is a measure of school functioning: a purpose-designed literacy assessment, standardized (mean=0, sd=1).

Our analyses also include controls for socioeconomic background (mother's and father's years of education, wealth), demographic factors (age and sex), and prior educational performance (cognitive test scores in 2000, school based test scores in 2000, and years of education attained).

3.3 Analytic Approach

We first describe the scale of food insecurity and nutritional deprivation in rural Gansu. Next, we analyze food insecurity and nutritional deprivation measures as dependent variables, with an emphasis on the degree to which nutrition is linked to socioeconomic status. Finally, we conduct regression and propensity score matching analyses of the relationship of literacy achievement to food insecurity, before and after adjusting for long-term nutritional status, socioeconomic status, and children's prior academic performance. Most analyses will focus only on the original sample of target children, but for some regression models, we are able to use household random and fixed

effects specifications that capitalize on sibling data collected from the eldest younger school-aged sibling in 2004.

4 Results

4.1 Prevalence of Food Insecurity and Nutritional Deprivation

Table 1 shows food insecurity reported by mothers of target children in 2000 and 2004. Food insecurity dropped substantially among the households under study in this period, from about one-fourth of households to 7 percent. Among food insecure households in 2004, 36 percent of mothers reported that their families went hungry because of insufficient food or money to buy food; 41 percent reported having had to depend on relatives or friends to give food; 49 percent reported that they or their family had borrowed money from relatives or friends to buy food; and 23 percent reported having to cut food available for children because there was not enough food or money. Also among food insecure households, 9 percent of mothers reported that adults had had to go a full day without food due to lack of money or food, and 6 percent of mothers in food insecure households reported that children had had to do so.

[FIGURE 1. PROPORTION OF MOTHERS REPORTING THAT THEIR FAMILIES "ALMOST NEVER" CONSUMED EACH FOOD TYPE IN THE PAST MONTH BY FOOD INSECURITY STATUS, 2004]

An illustration of the difference between food secure and food insecure households is evident in mother's reports of family consumption patterns in the past month. Mothers were asked how frequently they and their families consumed various categories of food, and response options were "almost never", "one to three times," and "once a week or more". Figure 1 shows the proportion of mothers reporting that their families "almost never"

consumed various types of foods in the past month, by food insecurity status, from the 2004 data. The food types presented represent nutritious or "luxury" foods other than the staples of wheat-based foods (bread and noodles), potatoes, and yams. Figure 1 shows, first, that non-trivial proportions of food secure households in rural Gansu did not consume meat, eggs, fruit, or dairy products. Even for vegetables, which had the highest level of access among these food items, one in ten mothers in food secure households reported that her family almost never ate vegetables in the preceding month.

However, across the board, the lack of consumption of these foods was significantly more pronounced in food insecure households, and the difference, in some cases, was striking. For example, over three-fourths of mothers in food insecure households reported almost never consuming meat in the past month, compared to 39 percent of mothers in food secure households. Over half (57 percent) of mothers in food insecure households reported consuming no eggs, compared to 29 percent of mothers in food secure households. About 39 percent of mothers in food insecure households reported no consumption of vegetables, compared to 10 percent of mothers in food secure households. Corresponding numbers were 73 percent and 48 percent for fruits, and 96 percent and 79 percent for dairy products. All of these differences were statistically significant at conventional levels.

[TABLE 2. NUTRITIONAL STATUS AND FOOD SECURITY MEASURES FOR THE TARGET CHILD SAMPLE, THE OLDEST YOUNGER SCHOOL-AGE SIBLING SAMPLE, AND THE COMBINED CHILD SAMPLE.]

Table 2 shows nutritional status and food security measures for the target child, oldest younger school-age sibling, and combined samples. Table 2 shows that on average, target children are 1.24 standard deviations below the reference mean height-for-age, and 1.33 standard deviations below the reference mean weight-for-age. Using a two standard

deviation cutoff, about one in five children in the target sample were stunted and about one in four were severely underweight. Corresponding numbers were not very different for the sibling and combined samples.

4.2 Social Location of Food Insecurity and Nutritional Deprivation

[FIGURE 2. FOOD SECURITY AND NUTRITION MEASURES BY WEALTH QUINTILE, 2004.]

Poor nutrition and household food insecurity are closely linked to wealth. Figure 2 shows means and proportions for nutritional status and food insecurity measures by wealth quintile for the target child sample in 2004. The wealthiest children in the sample face less of a lesser risk for poor nutrition by the anthropometric measures. The poorest fifth of children in the sample are 1.9 times as likely to be stunted as the wealthiest children, and 1.7 times as likely to be severely underweight as the wealthiest children. The poorest fifth of children in the sample are five times as likely as the wealthiest fifth to be resident in food insecure households. The standardized food insecurity severity index shows that the poorest fifth of children face greater severity of food insecurity, compared to children in less poor households.

[TABLE 3. ANALYSIS OF THE SOCIAL LOCATION OF NUTRITIONAL DEPRIVATION AND FOOD INSECURITY, CHILD SAMPLE, 2004.]

Table 3 illustrates further the links between poverty, nutritional deprivation, and food insecurity, modeling anthropometric measures and food insecurity as functions of socioeconomic status and demographics. Table 3 confirms that Height-for-age is related to higher wealth (top two quintiles) and mother's education, as shown in the random effects specification. Moreover, as children get older, they fall behind in height-for-age, which is

shown in both the random effects specification, and slightly more strongly in the fixed effects specification that accounts for unobserved household differences. Weight-for-age shows a significant benefit to children in the highest wealth quintile, and for children of better-educated mothers. Children fall behind with higher age, a finding present in both specifications, and girls have significantly higher weight-for-age than do boys.

The poorest children are also at high risk for food insecurity, by the mother report measures. Table 3 speaks to significant effects of wealth quintile on food insecurity for those in the top three wealth quintiles, net of parental education and other variables in the model. The probability of being in an insecure household decreases by about .06 for those in the wealthiest two quintiles, compared to the poorest (model 3a). This effect is substantively important, given that the estimated overall probability of food insecurity, all variables held to means, is about .06 (not shown). Wealth differences between the poorest fifth of households and other households are also present in model 3b, which uses the food insecurity severity measure. However, the proportion of variance explained in this model is very low. This situation may reflect an observation, based on the US literature, that while the populations affected by food insecurity and poverty overlap, they are not identical (Cook and Frank 2008).

4.3 Food Insecurity, Nutritional Deprivation, and School Functioning

[TABLE 4. MODELS OF LITERACY, TARGET CHILD SAMPLE, 2004.]

Do these measures predict literacy achievement? Table 4 shows estimates from models of standardized literacy scores assessed in 2004 against the nutrition and food insecurity measures, along with socioeconomic status and prior achievement. In the

baseline specifications that control for child age and sex alone (model 1) and then for socioeconomic status (model 2), we see that height-for-age and food insecurity are each significantly associated with literacy scores in 2004. The significant effect of height-for-age, which is a proxy for nutrition early in life, disappears in the model that incorporates controls for early academic achievement and educational attainment (end-of-term test scores and a cognitive test score, model 3a). The wealth effects also disappear in this specification. These findings suggest that nutritional status may be operating through conditioning early school experiences.

However, net of these controls, food insecurity is associated with about one-third of a standard deviation lower literacy score. These coefficients suggest non-trivial effects—they can be compared with the effect of a year of child's educational attainment, which yields about a .25 standard deviation increase in literacy scores (Table 3, model 3a). Finally, the food insecurity severity index similarly shows a highly significant effect, indicating that children with greater food insecurity severity achieve lower literacy scores.

[TABLE 5. PROPENSITY SCORE MATCHING ESTIMATES, EFFECT OF FOOD INSECURITY ON STANDARDIZED LITERACY ACHIEVEMENT.]

A more conservative test of the food insecurity findings can be generated by using a propensity score matching approach. In this approach, food insecure households—the "treatment" group—are matched to other similar but not food insecure households. Next, the literacy difference between treatment and control groups is estimated on the matched sample. We estimated the propensity to be in food-insecure households using the same independent variables as shown in model 3, Table 4.[iii] Significant differences in predictors were across food insecure and food secure households were present for many variables in

the unmatched sample, but these differences were eliminated for all variables in the matched sample (See appendix table A-2). Results show that, for the matched sample, the average treatment effect on the treated is -.39 standard deviations, which is in the range of estimates obtained in Table 4.

5 Discussion and Conclusions

Using data from a survey of children from 100 rural villages in Gansu Province, we have investigated the association of food insecurity with poverty, and then compared the literacy skills of children in food secure and food insecure households. We show, first, that poor nutrition and food insecurity are commonly associated with poverty: children in the poorest households are at elevated risk for nutritional deprivation and food insecurity. Next, we show that early nutritional status, proxied by height-for-age, was significantly associated with literacy achievement, but those results become insignificant once prior achievement is controlled. This finding suggests the importance of nutrition at early educational stages. Most strikingly, our results show that even in the most conservative regression models with full controls for socioeconomic status, prior educational achievement and early nutritional status, and in matched samples estimates, children in food insecure households have significantly lower literacy scores.

A logical and plausible inference from these findings is that nutritional deprivation and food insecurity are important mechanisms of the transmission of educational disadvantage for the poorest children in China. One could argue that our nutrition and food insecurity measures may operate in part as proxies for other unmeasured dimensions of poverty. Because of the careful measurement of wealth, parental education, and prior

achievement, and our inclusion of these measures in our final model, we do not believe that our results can be fully accounted for by this problem. However, even if this problem is present, our findings lead to a still-useful conclusion that stunting and food insecurity are easily-measurable risk factors for educational disadvantage. Either a causal or a proxy interpretation of our findings suggests the importance of theorizing nutritional deprivation and food insecurity in conjunction with poverty, and incorporating these concepts as a matter of course in studies of childhood poverty and educational mobility.

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[i] According to the same guidelines (Cook and Frank 2008, p. 193), a food secure household is one in which there is "Access by all people at all times to enough food for an active, healthy life. Food security includes, at a minimum: (1) the ready availability of nutritionally adequate and safe foods and (2) an assured ability to quire acceptable foods in socially acceptable ways (e.g., without resorting to emergency food supplies, scavenging, stealing, or other coping strategies).

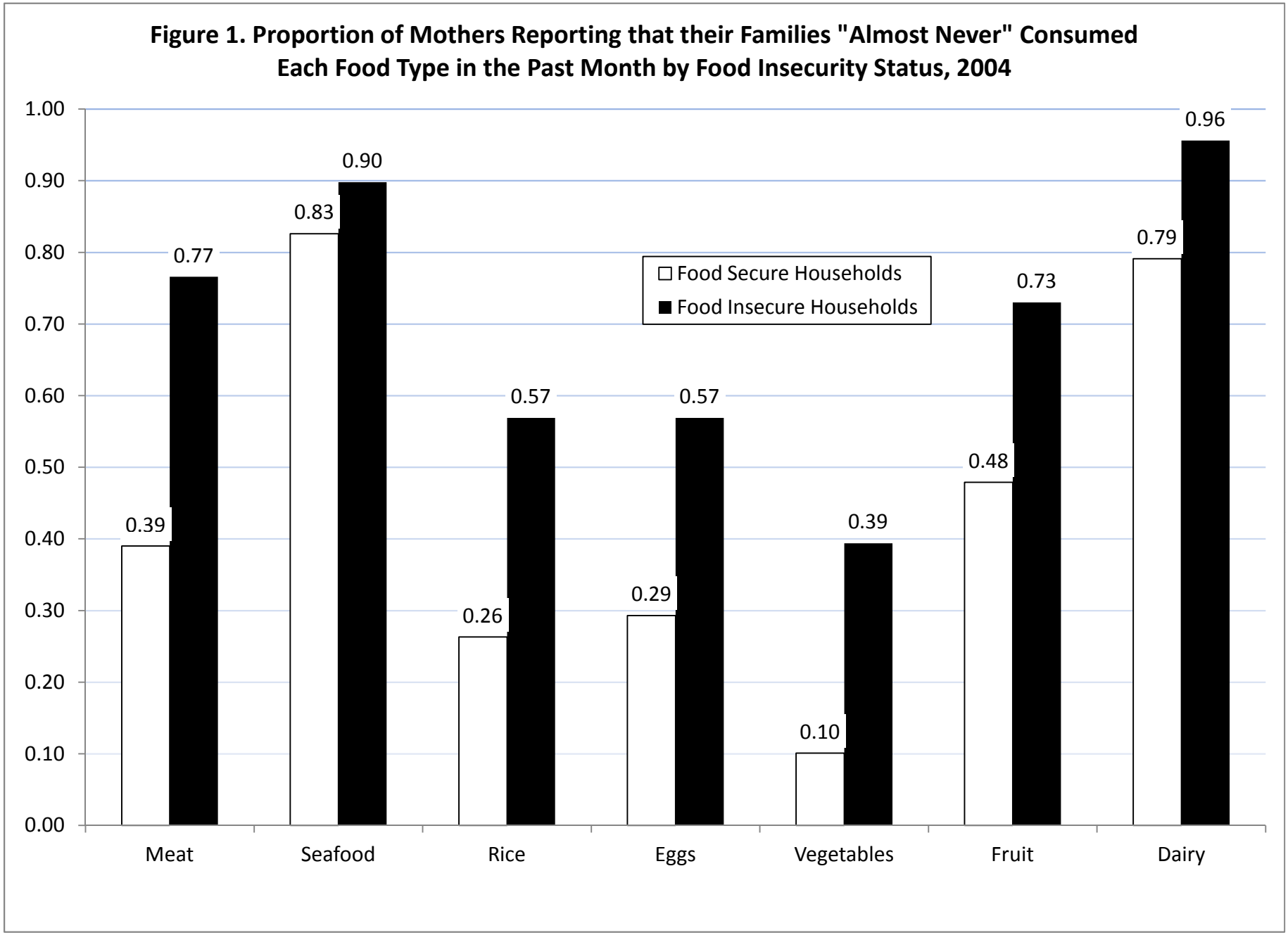
[ii] Cook and Frank (2008, p. 194) report on a standard Food Security Scale and a Children's Food Security Scale that have been scored and validated in the United States. Our index adapted this approach to the context of rural China, and the context of a multipurpose survey. Our study contains a similar but smaller set of items.

[iii] We use the *psmatch2* program in Stata to estimate propensity scores for glasses-wearing, with kernel matching. We use logit models for estimation of propensity scores. We imposed a common support structure (for a straightforward discussion of the implications of model choice, matching choice, and common support, see Caliendo and Kopeinig, 2008).

Table 1. Food Insecurity Reported by Mothers of Target Children, 2000 and 2004

	Mean	SD	N
Food Insecure, 2000	0.26	0.44	1,999
Food Insecure, 2004	0.07	0.26	1,866
Food Insecurity Severity Index, 2004	0.00	0.70	1,866
Among food Insecure in 2004, Proportion Reporting "Yes" for the Past Year:			
You or your family ever went hungry because you did not have enough food or enough money to buy food?	0.36	0.48	137
You or your family ever had to depend on relatives or friends to give you some food?	0.41	0.49	137
You or your family ever had to borrow money from relatives or friends to buy food?	0.49	0.50	137
Ever had to purposely cut the amount of food for children (under 16) because there was not enough food, or no money to buy enough food?	0.23	0.42	137
You or anyone in your family who is older than 16 ever had to go hungry for a whole day because there was no food?	0.09	0.28	137
Children (under 16) ever had to go hungry for a whole day because there was no food?	0.06	0.24	137

Source: Gansu Survey of Children and Families, 2000 and 2004



Note: All differences by household food insecurity status are significant at the .05 level or better. Source: Gansu Survey of Children and Families.

Summary statistics mean
by categories of oodinsecurst year, fooc

foodinsecure			Meat	Seafood	Rice	Eggs	Vegetables	Fruit
always	enough	secure Hous	0.39	0.83	0.26	0.29	0.10	0.48
not	enough	secure Hou	0.77	0.90	0.57	0.57	0.39	0.73
Total			0.418	0.832	0.286	0.313	0.123	0.498

Source: figure1data.xml, produced by logout command in FS_literacy_analyses_201008.do, Oct. 10 20

Summary statistics: mean
by categories of: foodinsecu (in the past year,

foodinsecure			mf1_no~t	mf2_no~f	mf3_no~e	mf4_no~s	mf5_no~g	mf6_no~t
	always	enough	0.39	0.83	0.26	0.29	0.10	0.48
not	enough	food	0.77	0.90	0.57	0.57	0.39	0.73
	Total		0.42	0.83	0.29	0.31	0.12	0.50
			0.00	0.00	0.00	0.00	0.00	0.00
			0.00	0.00	0.00	0.00	0.00	0.00
			0.00	0.00	0.00	0.00	0.00	0.00

Dairy
0.79
0.96
0.803

10

food situation)

mf7_no~y

0.79
0.96

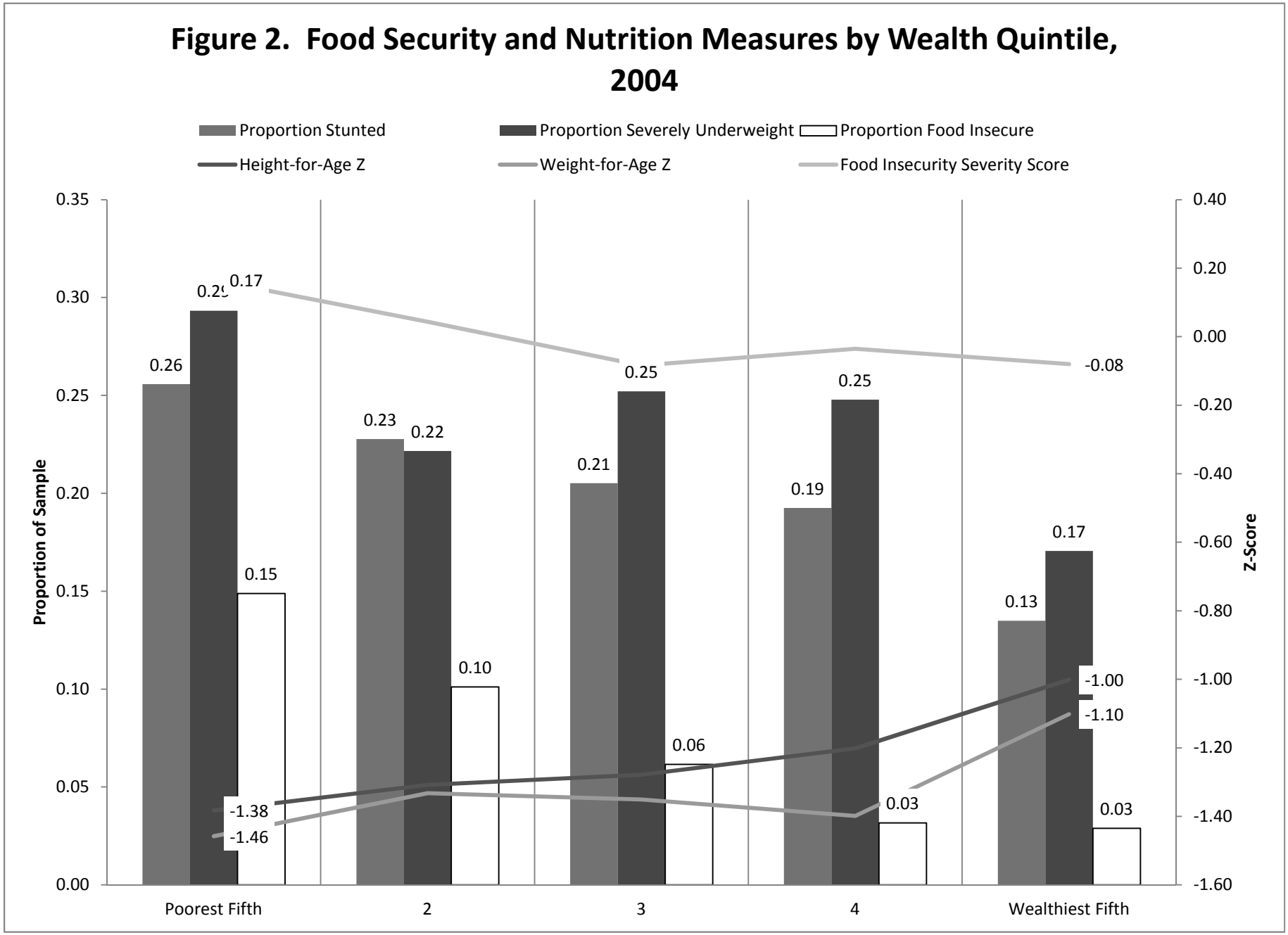
0.80

0.00
0.00
0.00

Table 2. Nutrition and Food Security Measures, Child and Sibling Samples, 2004

	Child Sample			Sibling Sample			Full Sample		
	Mean	SD	N	Mean	SD	N	Mean	SD	N
Height-for-Age Z	-1.24	1.02	1,731	-1.16	1.23	710	-1.21	1.08	2,441
Weight-for-Age Z	-1.33	1.10	1,716	-1.37	1.24	714	-1.34	1.14	2,430
Proportion Stunted	0.20	0.40	1,731	0.24	0.43	710	0.21	0.41	2,441
Proportion Severely Underweight	0.24	0.43	1,716	0.29	0.46	714	0.25	0.44	2,430
Proportion Food Insecure	0.07	0.26	1,866	---	---	---	---	---	---
Food Insecurity Severity Index	0.00	0.70	1,866	---	---	---	---	---	---

Source: Gansu Survey of Children and Families, 2004. Note: Stunting and wasting=<-2 Z score for height and for weight, respectively.



Source: Gansu Survey of Children and Families.

Summary	statistics	mean		
by	categories	of	wealth5	(5 quantiles of wealth2)
	Height-for-Age	eight-for-Ag	Proportion Stunted	portion Severely Underwe
Poorest Fifth		-1.38	-1.46	0.26	0.29
	2	-1.31	-1.33	0.23	0.22
	3	-1.28	-1.35	0.21	0.25
	4	-1.20	-1.40	0.19	0.25
Wealthiest Fifth		-1.00	-1.10	0.13	0.17

Source: figure2data.xml, produced by logout command in FS_literacy_analyses_201008

Notes for text:	Stunted	Wasted
Poorest/Wealthiest:	1.90	1.7

wealth5	z_ht_us	z_wt_us	low_ht~s	low_wt~s
1	-1.38316	-1.45821	0.255814	0.293255
2	-1.30792	-1.33241	0.227666	0.221574
3	-1.27869	-1.3505	0.205128	0.252149
4	-1.20137	-1.39888	0.192529	0.247813
5	-1.00119	-1.10144	0.134897	0.170588
Total	-1.2351	-1.32861	0.203351	0.23718

Proportion Food Insecure	Food Insecurity Severi
0.15	0.17
0.10	0.04
0.06	-0.08
0.03	-0.04
0.03	-0.08

	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00
3.do, Oct. 10 2010	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00
Food Insecure	0.00	0.00	0.00	0.00
5				

foodin~e	fi_score
0.148876	0.165299
0.101064	0.043738
0.061497	-0.08392
0.031662	-0.03528
0.028871	-0.08015
0.073419	-1.09E-08

0.00	0.00
0.00	0.00
0.00	0.00
0.00	0.00
0.00	0.00
0.00	0.00

wealth2)

Table 3. Analysis of the Social Location of Nutritional Deprivation and Food Insecurity, Child Sample, 2004

	(1)				(2)				(3)			
	Height-for-Age Z-Scores				Weight-for-Age Z-Scores				Food Insecurity			
	(a)		(b)		(a)		(b)		(a)		(b)	
	Regression with Household Random Effects		Regression with Household Fixed Effects		Regression with Household Random Effects		Regression with Household Fixed Effects		Marginal Effects, Logit Specification		Regression of Food Insecurity Severity Index	
	coef	se	coef	se	coef	se	coef	se	coef	se	coef	se
Wealth Quintiles (Ref=Poorest Fifth)												
Second	0.085	*0.072*	---		0.133*	*0.076*	---		-0.017	*0.011*	-0.124**	*0.054*
Third	0.066	*0.073*	---		0.114	*0.077*	---		-0.040***	*0.010*	-0.248***	*0.054*
Fourth	0.175**	*0.073*	---		0.076	*0.078*	---		-0.061***	*0.010*	-0.201***	*0.054*
Wealthiest Fifth	0.271***	*0.075*	---		0.279***	*0.079*	---		-0.064***	*0.010*	-0.249***	*0.055*
Mother's Education	0.023***	*0.007*	---		0.020***	*0.008*	---		-0.001	*0.002*	0.005	*0.005*
Father's Education	0.006	*0.007*	---		-0.005	*0.008*	---		-0.003*	*0.002*	-0.006	*0.005*
Age	-0.095***	*0.012*	-0.112***	*0.017*	-0.052***	*0.013*	-0.084***	*0.018*	-0.003	*0.005*	-0.002	*0.015*
Female	0.060	*0.042*	0.129*	*0.069*	0.163***	*0.046*	0.234***	*0.075*	0.008	*0.011*	0.044	*0.034*
Constant	-0.177	*0.171*	0.276	*0.228*	-0.859***	*0.184*	-0.293	*0.249*			0.192	*0.224*
Sample	Combined Sibling		Combined Sibling		Combined Sibling		Combined Sibling		Target Child Only		Target Child Only	
N	2,439		2,439		2,428		2,428		1,699		1,699	
rho	*0.236*		*0.535*		*0.196*		*0.518*		---		0.015	

Notes: *** p<0.01, ** p<0.05, * p<0.1. Parental education measures are set to 0 if parents have died. Models also include dummy variables indicating if mother died or father died.

Table 4. Models of Literacy, Target Child Sample, 2004.

		(1)		(2)		(3a)		(3b)	
		Baseline, Dichotomous Food Insecurity		Socioeconomic Controls, Dichotomous Food Insecurity		Prior ability and Achievement, Dichotomous Food Insecurity		Prior ability and Achievement, Food Insecurity Severity Index	
		coef	se	coef	se	coef	se	coef	se
Height-for-Age Z		0.142***	*0.034*	0.106***	*0.023*	0.019	*0.021*	0.023	*0.021*
Weight-for-Age Z		-0.014	*0.031*						
Food Insecurity		-0.524***	*0.094*	-0.406***	*0.094*	-0.335***	*0.084*	-0.102***	*0.037*
Age		0.185***	*0.022*	0.173***	*0.022*	-0.028	*0.023*	-0.026	*0.023*
Female		-0.242***	*0.049*	-0.215***	*0.047*	-0.158***	*0.042*	-0.157***	*0.043*
Wealth Quintiles	Second			0.131*	*0.076*	0.046	*0.068*	0.047	*0.069*
(Ref.=Poorest)	Third			0.150**	*0.076*	0.045	*0.068*	0.048	*0.068*
	Fourth			0.173**	*0.076*	0.031	*0.068*	0.043	*0.069*
	Fifth			0.275***	*0.078*	0.065	*0.071*	0.074	*0.071*
Mother's Education (Years)				0.037***	*0.007*	0.014**	*0.007*	0.014**	*0.007*
Father's Education (Years)				0.026***	*0.007*	0.003	*0.007*	0.004	*0.007*
Prior Cognitive Test (2000)						0.012***	*0.002*	0.012***	*0.002*
Prior Math Achievement (2000)						0.005**	*0.002*	0.005*	*0.002*
Prior Language Achievement (2000)						0.001	*0.002*	0.002	*0.002*
Grade Attained						0.246***	*0.017*	0.245***	*0.017*
Constant		-2.356***	*0.326*	-2.718***	*0.320*	-1.978***	*0.321*	-2.047***	*0.321*
N		1,511		1,526		1,521		1,521	
Adjusted r-squared		0.090		0.135		0.308		0.304	

Notes: *** p<0.01, ** p<0.05, * p<0.1. Parental education measures are set to 0 if parents have died. Models also include dummy variables indicating if mother died or father died.

Table 5. Propensity Score Matching Estimates, Effect of Food Insecurity on Standardized Literacy Achievement (Average Treatment Effect on the Treated, ATT), Child Sample, 2004

Sample	Treated	Controls	Difference	S.E.	T-stat
Unmatched	-0.51	0.06	-0.57	0.10	-5.89
Matched	*-0.50*	*-0.12*	***-0.39***	*0.12*	*-3.21*

Note: Propensity score equations contain all variables shown Model 3a in Tables 4-6, with the dichotomous food insecurity measure as the treatment. Kernel matching is used.

Child

Variable	Obs	Mean	Std. Dev.	Min	Ma
sttotal	1746	-0.00063	1.000409	-3.3005	1.876986
z_ht_us	1731	-1.2351	1.017692	-4.9566	1.8121
z_wt_us	1716	-1.32861	1.102467	-4.97697	2.458443
foodinsec~00	1999	0.258129	0.437715	0	1
foodinsecure	1866	0.073419	0.260893	0.00E+00	1
fi_score	1866	-1.09E-08	0.698228	-0.12506	14.30571
mf1_nomeat	1866	0.418006	0.493364	0	1
mf2_noseaf	1866	0.831726	0.37421	0	1
mf3_norice	1866	0.285638	0.451839	0	1
mf4_noeggs	1866	0.312969	0.463826	0	1
mf5_noveg	1866	0.122722	0.328206	0	1
mf6_nofruit	1866	0.497856	0.500129	0	1
mf7_nodairy	1866	0.802787	0.398001	0	1
_Iwealth5_2	1918	0.200209	0.400261	0	1
_Iwealth5_3	1918	0.199687	0.399869	0	1
_Iwealth5_4	1918	0.200209	0.400261	0	1
_Iwealth5_5	1918	0.199687	0.399869	0	1
med	1918	4.261731	3.492343	-8	13
fed	1918	6.946298	3.600518	0	20
motherdied	1916	0.008873	0.0938	0	1
fatherdied	1918	0.01877	0.135746	0	1
renzhi	1999	17.6082	10.21701	0	68
db12a	1980	71.41505	15.85493	-2	100
db13a	1980	73.08227	16.63337	-2	100
educatt	1917	7.133542	1.821613	0	13
ageyears	1781	14.5087	1.11454	10	20
female	1918	0.469239	0.499183	0	1

Sibling

Variable	Obs	Mean	Std. Dev.	Min	Ma
sttotal	1	0.097226	.	0.097226	0.097226
z_ht_us	710	-1.16344	1.226672	-4.81542	4.257339
z_wt_us	714	-1.37146	1.236533	-4.9108	2.798144
foodinsec~00	885	0.279096	0.448809	0	1
foodinsecure	893	0.091825	0.288941	0	1
fi_score	0				
mf1_nomeat	893	0.43897	0.496539	0	1
mf2_noseaf	893	0.844345	0.362731	0	1
mf3_norice	893	0.301232	0.45905	0	1
mf4_noeggs	893	0.344905	0.475604	0	1
mf5_noveg	893	0.12542	0.33138	0	1
mf6_nofruit	893	0.50168	0.500277	0	1

mf7_nodairy	893	0.825308	0.379916	0	1
_Iwealth5_2	916	0.218341	0.413346	0	1
_Iwealth5_3	916	0.184498	0.388102	0	1
_Iwealth5_4	916	0.196507	0.397573	0	1
_Iwealth5_5	916	0.179039	0.383595	0	1
med	916	4.101528	3.338721	0	13
fed	916	6.915939	3.491211	0	20
motherdied	916	0.007642	0.087131	0	1
fatherdied	916	0.0131	0.113767	0	1
renzhi	0				
db12a	0				
db13a	0				
educatt	895	4.735196	2.055233	0	10
ageyears	759	12.05534	1.971993	6	17
female	896	0.417411	0.493407	0	1

Total

Variable	Obs	Mean	Std. Dev.	Min	Ma
sttotal	1748	-0.0007	0.999853	-3.3005	1.876986
z_ht_us	2441	-1.21426	1.082875	-4.9566	4.257339
z_wt_us	2430	-1.3412	1.143399	-4.97697	2.798144
foodinsec~00	2884	0.264563	0.441177	0	1
foodinsecure	2759	0.079377	0.270375	0	1
fi_score	1866	-1.09E-08	0.698228	-0.12506	14.30571
mf1_nomeat	2759	0.424792	0.494401	0	1
mf2_noseaf	2759	0.83581	0.370515	0	1
mf3_norice	2759	0.290685	0.454161	0	1
mf4_noeggs	2759	0.323306	0.467823	0	1
mf5_noveg	2759	0.123596	0.329179	0	1
mf6_nofruit	2759	0.499094	0.50009	0	1
mf7_nodairy	2759	0.810076	0.392312	0	1
_Iwealth5_2	2834	0.206069	0.404552	0	1
_Iwealth5_3	2834	0.194778	0.396099	0	1
_Iwealth5_4	2834	0.199012	0.399328	0	1
_Iwealth5_5	2834	0.193013	0.394733	0	1
med	2834	4.209951	3.443666	-8	13
fed	2834	6.936486	3.564967	0	20
motherdied	2832	0.008475	0.091683	0	1
fatherdied	2834	0.016937	0.129059	0	1
renzhi	1999	17.6082	10.21701	0	68
db12a	1980	71.41505	15.85493	-2	100
db13a	1980	73.08227	16.63337	-2	100
educatt	2812	6.370199	2.203101	0	13
ageyears	2540	13.77559	1.814788	6	20
female	2814	0.452736	0.49785	0	1

x

Standardized Literacy Assessment		
Height-for-Age Z		
Weight-for-Age Z		
	Food Insecurity, 2000	
	Food Insecurity, 2004	
Severity of Food Insecurity (Index)		
Past Month, "Almost Never" Consumed…		Meat
		Seafood
		Rice
		Eggs
		Vegetables
		Fruit
		Dairy
Wealth Quintiles	Second	
(Ref.=Poorest)	Third	
	Fourth	
	Fifth	
Mother's Education (Years)		
Father's Education (Years)		
Mother Passed Away		
Father Passed Away		
Prior Cognitive Test (2000)		
Prior Math Achievement (2000)		
Prior Language Achievement (2000)		
Grade Attained		
Age		
Female		

x

x

Appendix Table A-1. Descriptive Statistics, Child, Sibling and Full Samples

		N	Mean	Std. Dev.
Child Sample				
Standardized Literacy Assessment		1746	0.00	1.00
Height-for-Age Z		1731	-1.24	1.02
Weight-for-Age Z		1716	-1.33	1.10
Food Insecurity, 2000		1999	0.26	0.44
Food Insecurity, 2004		1866	0.07	0.26
Severity of Food Insecurity (Index)		1866	0.00	0.70
Past Month, "Almost Never" Consumed…	Meat	1866	0.42	0.49
	Seafood	1866	0.83	0.37
	Rice	1866	0.29	0.45
	Eggs	1866	0.31	0.46
	Vegetables	1866	0.12	0.33
	Fruit	1866	0.50	0.50
	Dairy	1866	0.80	0.40
Wealth Quintiles	Second	1918	0.20	0.40
(Ref.=Poorest)	Third	1918	0.20	0.40
	Fourth	1918	0.20	0.40
	Fifth	1918	0.20	0.40
Mother's Education (Years)		1918	4.26	3.49
Father's Education (Years)		1918	6.95	3.60
Mother Passed Away		1916	0.01	0.09
Father Passed Away		1918	0.02	0.14
Prior Cognitive Test (2000)		1999	17.61	10.22
Prior Math Achievement (2000)		1980	71.42	15.85
Prior Language Achievement (2000)		1980	73.08	16.63
Grade Attained		1917	7.13	1.82
Age		1781	14.51	1.11
Female		1918	0.47	0.50
Sibling Sample				
Height-for-Age Z		710	-1.16	1.23
Weight-for-Age Z		714	-1.37	1.24
Age		759	12.06	1.97
Female		896	0.42	0.49

Appendix Table A-2. Comparison of Samples, Pre- and Post-matching

		Mean		Bias		T-Test	
	Sample	Treated	Control	%	% Reduction	T	P>T
Height-for-Age Z	Unmatched	-1.33	-1.34	1.20		0.15	0.88
	Matched	-1.36	-1.50	11.50	-899.40	0.82	0.41
Weight-for-Age Z	Unmatched	-1.38	-1.19	-16.90		-2.25	0.03
	Matched	-1.49	-1.50	1.00	93.80	0.08	0.94
Wealth Quintile=2	Unmatched	0.30	0.20	22.60		3.41	0.00
	Matched	0.27	0.30	-8.00	64.50	-0.55	0.58
Wealth Quintile=3	Unmatched	0.16	0.20	-11.60		-1.59	0.11
	Matched	0.16	0.17	-0.70	94.30	-0.05	0.96
Wealth Quintile=4	Unmatched	0.09	0.21	-34.00		-4.26	0.00
	Matched	0.09	0.08	0.70	98.00	0.06	0.95
Wealth Quintile=5	Unmatched	0.07	0.21	-39.50		-4.83	0.00
	Matched	0.09	0.07	4.70	88.20	0.42	0.67
Mother's Education (Years)	Unmatched	3.37	4.35	-27.70		-4.09	0.00
	Matched	3.57	3.52	1.30	95.20	0.10	0.92
Father's Education (Years)	Unmatched	6.12	7.05	-25.60		-3.73	0.00
	Matched	5.91	5.91	0.20	99.10	0.02	0.99
Indicator, Father Passed Away	Unmatched	0.01	0.02	-6.90		-0.87	0.38
	Matched	0.02	0.02	-0.90	87.00	-0.05	0.96
Prior Cognitive Test (2000)	Unmatched	13.70	17.90	-41.70		-4.72	0.00
	Matched	13.47	13.80	-3.30	92.00	-0.25	0.80
Prior Math Achievement	Unmatched	68.86	71.60	-17.60		-1.93	0.05
	Matched	68.49	68.70	-1.40	92.20	-0.09	0.93
Prior Language Achievement	Unmatched	68.46	73.34	-29.50		-3.27	0.00
	Matched	68.37	68.75	-2.30	92.20	-0.15	0.88
Grade Attained	Unmatched	5.77	6.44	-29.90		-4.33	0.00
	Matched	6.68	6.78	-4.40	85.40	-0.38	0.70
Age	Unmatched	13.59	13.79	-11.30		-1.46	0.14
	Matched	14.39	14.43	-1.90	82.80	-0.23	0.82
Female	Unmatched	0.46	0.45	2.30		0.32	0.75
	Matched	0.50	0.51	-1.90	14.50	-0.14	0.89

Source: Gansu Survey of Children and Families. *Note:* Indicator for mother passed away dropped due to collinearity.