January 2007

Food for Thought: Poverty, Family Nutritional Environment, and Children's Educational Performance in Rural China

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Published in *Sociological Perspectives*, Volume 50, Issue 4, pp. 53–77, ISSN 0731-1214, electronic ISSN 1533-8673. DOI: 10.1525/sop.2007.50.1.53..

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Abstract

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FOOD FOR THOUGHT: POVERTY, FAMILY NUTRITIONAL ENVIRONMENT, AND CHILDREN'S EDUCATIONAL PERFORMANCE IN RURAL CHINA

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ABSTRACT: *Insecure access to nutritious food is a common experience for poor households in developing countries. Despite the global scale of food insecurity, it has not been conceptualized by sociologists as a significant component of home environment or dimension of poverty that might matter for children's outcomes. Analyzing data from rural China, the authors show that nutritional environment in the home is associated with household socioeconomic status, that it predicts children's school performance, and that it is a significant mediator of poverty effects on schooling for children in early primary grades.* Keywords: health and education; nutrition and education; home environment for learning; rural development; poverty and child welfare.

One out of every three children under five in developing countries is malnourished (Smith and Haddad 2000). The coincidence of economic deprivation and inadequate nutrition means that poor children in these countries are particularly vulnerable to risks of ill health and stunted growth. More insidiously, poor nutrition may curtail children's capacity to perform well at school. However, little sociological research has considered the role of nutrition in conditioning educational outcomes.

In China, the focus of this study, nutritional deprivation among children has diminished in recent years but remains a significant national problem. A recent national survey estimates that the stunting rate among children was 22.0 percent in 1998; in officially designated poor counties, stunting rates reach as high as 43 to 46 percent (Park and Wang 2001; Park and Zhang 2000).

Analyzing data from a survey of 2,000 nine- to twelve-year-old children and families in rural Gansu, China, we consider whether family nutritional environment

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Sociological Perspectives, **Vol. 50, Issue 4, pp. 53–77, ISSN 0731-1214, electronic ISSN 1533-8673.**
 DOI: 10.1525/sop.2007.50.1.53.

conditions school performance. We measure family nutritional environment using a scale derived from food frequency questions that indicate a household's access to a variety of nutritious foods. We operationalize school performance in two ways: first as average mathematics and language (Chinese) scores on examinations in the last semester and second as curriculum-based standard language and mathematics tests.

The article addresses two specific questions: First, does the nutritional environment in the home predict children's performance? Second, is the nutritional environment in the home a mechanism linking poverty and educational outcomes? The focus on nutrition brings a new perspective to the sociology of education literature, which has traditionally focused on economic, cultural, and social resources as the dominant mechanisms of social reproduction.

We begin by laying out a framework for our study and discussing the research basis for this framework in the China context. We then present the data and methods employed in the study and the main results of analysis. We conclude with a discussion of the results and their implications for further research. As we will argue later, our results suggest that for children in early primary grades, a favorable household nutritional environment positively predicts school performance. Furthermore, the positive effects of household economic resources on school performance are significantly reduced in models that consider nutritional environment in the home, suggesting that household nutrition is an important mechanism linking household poverty to school outcomes.

FRAMEWORK

The Resource Framework

Sociological research on poverty and children's school outcomes has increasingly adopted an integrated approach, focusing on children's homes, communities, and schools to better understand factors that provide opportunity and factors that impede it (Board on Children and Families et al. 1995). Brooks-Gunn et al. (1995) describe a "resource framework" for studying child and adolescent development. This framework formalizes an emerging tradition of an integrated approach to analyzing the effects of poverty on child development and education conducted in the United States (e.g., Booth and Dunn 1996; Brooks-Gunn et al. 1995; Brooks-Gunn, Duncan, and Aber 1997; Duncan and Brooks-Gunn 1997; Huston 1991).

The resource framework can be viewed as unifying various overlapping theoretical arguments that have emerged to explain the relationship between poverty and educational outcomes: (a) "material resource" arguments indicating that poor children suffer because their parents, communities, and schools lack the financial resources that can aid learning and achievement; (b) "human capital" arguments suggesting that poor children suffer because of the poorer endowments and investments they receive from their parents (Becker 1993; Mayer 1997) or, by extension, the poorer human resources in the schools they attend; (c) "social capital/network" arguments suggesting that impoverished parents and children lack supportive social relationships and networks within and outside of the family

necessary for aspiring to and achieving success (see Coleman 1988); and (d) "cultural capital" arguments suggesting that children of historically disadvantaged groups suffer because they lack the cultural environment at home that would allow them to connect to content in the classroom (e.g., Bourdieu 1977; Farkas et al. 1990; Lareau 1987).

Much of this literature has focused on U.S. settings. In developing country settings, the majority of educational studies have focused on family socioeconomic background and its effects on enrollment or attainment, or school effects on achievement. The resources emphasized have been human capital and material resources (for a review, see Buchmann and Hannum 2001). A few sociological studies have begun to consider the role of social and cultural resources in conditioning educational outcomes in developing country settings (e.g., Buchmann 2002). A major challenge in moving beyond studies of human and material resource effects, however, is that social and cultural resources are much more culturally circumscribed. The very different contexts in developing country settings mean that different types of social and cultural factors are likely to matter for school achievement, making standard measures difficult. Furthermore, factors traditionally outside the realm of material, human, social, and cultural resources may be particularly important in developing country settings.

Home Nutritional Environment as an Additional Resource

One important example is nutrition. Empirical research outside of sociology has consistently demonstrated that malnutrition and inadequate nutrient and energy intake are closely associated with poor school performance in less developed countries. For example, of the nine studies reviewed by Pollitt (1990), all reported significant links between nutritional status indicators and cognitive test scores or school performance indicators. Similarly, Sigman et al. (1989) found that in Kenya, better nourished children achieved higher composite scores on a test of verbal comprehension and Raven Progressive Matrices. Furthermore, malnourished girls were less attentive during classroom observations than their better nourished counterparts. In the Philippines, Florencio (1995) concluded that the academic performance of pupils with good nutritional status was significantly better than that of pupils with poor nutritional status, although the relationship varied by grade level and subject matter. Studies have also discussed how various common malnutrition problems, such as protein-energy malnutrition, micronutrient deficiency disorder, and helminthic (worm) infections, affect a child's school performance (Berkman et al. 2002; Pollitt 1997).

The validity of these relationships, however, remains in question. Strong associations of health and nutrition with educational outcomes do not necessarily indicate causal relationships. Behrman (1996) has observed that previous studies fail to incorporate into their analysis the probable endogenous nature of child health. Estimates are likely to be biased in one direction or the other because households may make decisions on child health and child schooling simultaneously. Using data from the Ghanaian Living Standards Measurement Survey, Behrman and

Lavy (1994) found that with family and community fixed effects, the true effects of child health on school success were nearly zero, in direct contrast to statistically significant results obtained via traditional ordinary least squares and instrumental variables approaches. On the other hand, Alderman et al. (1997) dealt with endogeneity problems through a longitudinal approach. Results suggested that children's health and nutrition were three times more important for enrollment than were suggested by the assumption that children's health and nutrition are predetermined or exogenous.

Adopting yet a different strategy, Gomes-Neto et al. (1997) dealt with the possibly endogenous nature of child health by including prior achievement to lessen any potential impact of previous family investment. Results showed that students' nutritional status did affect school performance in rural northeast Brazil. Similarly, a recent study on a large sample of Filipino children by Glewwe, Jacoby, and King (2001) suggested a causal link between nutrition and academic success, controlling for heterogeneity in learning endowments, home environment, and parental preferences.

However, available studies of nutrition and education in developing countries have exclusively considered nutritional status as an individual characteristic and have not tried to conceptualize nutrition at the level of the household. From a sociological perspective, for understanding mechanisms of advantage and disadvantage for children, it is important to consider how nutritional environment in the home operates together with other home environmental factors to affect a child's active learning capacity (Levinger 1996). Returning to the resource framework, one potentially important conjecture is that the nutritional environment in the home may be an additional resource, along with cultural, social, and material resources, that matters for children's educational achievement. Some studies focusing on children's own nutritional status are consistent with this hypothesis. For example, Florencio's (1995) Philippine study showed that the positive relationship between academic performance and nutritional status holds while controlling for family income, school quality, teacher ability, and mental ability. Another study showed that regardless of the economic resources of the family, children who had more adequate diets scored higher on the cognitive tests than those with less adequate intake (Sigman et al. 1989).

A second conjecture is that nutritional environment in the home works in concert with material resource constraints and possibly acts as a mechanism by which poverty affects school outcomes. With regard to the former point, certain studies suggest that factors such as family income and parental education could protect children against the negative effects of malnutrition or could exacerbate those effects (Brown and Pollitt 1996). Others have noted that the disadvantage accruing to children's academic performance would not be fully corrected by improving the nutritional and health status alone, as malnutrition occurs primarily in poor environments where many other deprivations exist that may also limit children's development (Florencio 1995). To our knowledge, no studies in developing countries have sought to address the question of whether and to what degree the nutritional environment in the home matters for school achievement or works as a mechanism of poverty effects on achievement.

THE CHINA CONTEXT

Studies of education in China have documented social disparities in enrollment and attainment and attested to the disadvantaged position of rural children in remote regions such as Gansu, especially the poor (Brown and Park 2002; Connelly and Zheng 2000; Hannum 1999, 2002). Many have focused on the significance of household poverty for educational outcomes (e.g., Hannum 2003). Most studies have focused on enrollment or attainment as an outcome. Few have employed measures of achievement, and few have considered the home environment or accounted for school resources.

Although inadequate nutrition remains a serious problem in China's poor rural households, studies of rural children's nutrition and schooling are few. Nutrition studies have been primarily descriptive. Chen (2000) shows that the prevalence of malnutrition among Chinese children declined from 1990 to 1995 but that regional differences remain large, with malnutrition persisting in rural and underdeveloped areas. Undernutrition remains an important problem among children in rural areas, especially among young and poor groups (Park and Zhang 2000; Wang, Popkin, and Zhai 1998).

In China, the single study that has linked child nutritional status to school achievement used a data set of 3,000 children from five different provinces in 1979 (Jamison 1986). As Table 1 shows, Jamison found that height-for-age and weight-for-age measures of nutritional status predicted school performance, measured by grades behind. We replicated his models with more recent data from the 1993 China Health and Nutrition Survey (CHNS) but included a set of controls for children's socioeconomic background (see Table 1 and Appendix A for details).[1] This analysis shows that child's nutritional status continued to predict grades behind in the 1990s, net of household socioeconomic characteristics.

Findings thus suggest the importance of nutrition for schooling. However, they are limited by lack of direct measures of school achievement and by the

TABLE 1

Comparison: Regression of Grades Behind on Nutritional Status[a,b]

	Jamison (1986) *Grades Behind*[c]	*Yu and Hannum (2006)* *Grades Behind*[c]
Height-for-age	–0.029	–0.015
	(11.39)***	(4.45)***
Weight-for-age	–0.004	–0.003
	(4.22)**	(2.35)*
Control variables	Child's age, sex, geographic location[d]	Household per capita income, parental education, number of siblings, child's age and sex, geographic location[e], and residence

a. *Source*: Adapted from Table 3 of Jamison (1986) and analyses in Yu and Hannum (2006).

b. *T* values are shown in parentheses. *$p < .05$, **$p < 0.01$, ***$p < 0.001$ (two-tailed test).

c. The grades behind is calculated as the grade a child should be in, given his or her age minus his or her actual grade.

d. Provincial coverage: Beijing, Gansu (Lanzhou), Gansu (rural), Jiangsu (Nanjing), Jiangsu (rural).

e. Provincial coverage: Liaoning, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi, Guizhou.

limited availability of home and school environment variables likely correlated with poverty, school achievement, and nutritional status. Similar to other studies of nutrition and schooling, these models also conceptualize nutrition as an attribute of individuals rather than as an element of the home environment, raising questions about endogeneity and leaving unaddressed questions of how the nutrition-education relationship relates to household poverty. The analyses presented later seek to complement earlier research by addressing these limitations.

DATA AND METHODS

Data

The data used in this study come from the Gansu Survey of Children and Families (GSCF), a survey designed with the resource framework in mind. In the summer of 2000, 2,000 children ages nine to twelve and their families in rural areas of twenty counties in Gansu Province were interviewed (see Map 1). The sampling strategy involved a multistage cluster design with random selection procedures employed at each stage. At the final stage, children were sampled from lists of all nine- to twelve-year-old children in selected villages, enabling us to avoid concerns about selection bias that afflict school-based samples. Questionnaires were

Map 1
Gansu Province, GSCF Counties Marked

designed for the sample children and their mothers, fathers, teachers, principals, and village leaders.

Study Site

Gansu, the study site, exhibits conditions that are common in the interior part of China and elsewhere in the rural developing world. Although rural industries have emerged as in other parts of China with the economic liberalization dating from the early 1980s, rural residents are predominantly employed in subsistence farming or animal husbandry. Gansu's socioeconomic profile resembles that of other interior provinces: relative to the nation as a whole, Gansu exhibits high rates of illiteracy, prevalent poverty, and lackluster economic growth. Funds available for educational investments are also limited. As one of China's poorest provinces, Gansu provides a useful case study for investigating factors affecting school outcomes in a less developed setting.

Measures

School performance

We measure school performance in two ways. First we employ average language (Chinese) and math test scores from classroom exams. These scores were provided by sample children's homeroom teachers. The tests were conducted in the students' own classrooms. The scores were measured on a 100-point scale, with a score of 60 representing a passing grade. The average language and math scores of the sample children are 72.5 and 74.0, respectively (see Table 2). These tests have the disadvantage of not being standard in content across the province, but they have particular meaning as a measure of student performance as high-stakes tests that determine student promotion.

We also measure children's school achievement with standardized curriculum-based language (Chinese) and mathematics tests created specifically for the survey. The tests were designed by experts at the Gansu Educational Commission to cover the range of official primary school curriculum. On a random basis, half of the children completed the language test and the other half completed the math test. To ensure that the tests assessed an appropriate range of knowledge given the child's education, separate exams were given to children in grades three and below and to children in grades four and above. The tests were scored from 0 to 100. Table 2 shows that mean scores on Chinese and math, for children in grades three and below and grades four and above, are 32.4, 33.2, 41.7, and 36.2, respectively.

Nutritional Environment

Unlike height or other individual-level nutritional status measures used in most previous studies, our analysis uses mother reports of household access to a variety of nutritious foods in the home as an indicator of family nutritional environment. One advantage of using household-based measures is that we can avoid some potential endogeneity problems, assuming that households do not make

TABLE 2
Descriptive Statistics for School Achievement and Children's Background

	Mean/ Percentage	*Standard Deviation*	*Observation*
Average Semester Scores			
Chinese (100-point scale)	72.5	13.2	1,951
Math (100-point scale)	74.0	14.6	1,957
Curriculum-based standardized scores:			
Chinese (100-point scale, third grade and below)	32.4	23.6	581
Chinese (100-point scale, fourth grade and above)	33.2	17.7	421
Math (100-point scale, third grade and below)	41.7	27.5	525
Math (100-point scale, fourth grade and above)	36.2	20.6	414
Nutritional environment[a]	3.4	1.0	2,000
Age of child (years)	11.0	1.1	1,970
Household expenditures (Chinese currency: Yuan)	11,629.2	8,483.2	2,000
Household expenditures (log)	9.2	0.5	2,000
Books in the home	21.5	15.2	2,000
Male	53.9		2,000
Mother's education (years)			2,000
Zero	29.8		
One to six	43.6		
Seven to nine	22.6		
Ten and above	4.1		
Number of siblings			2,000
Zero	7.2		
One	61.6		
Two	25.4		
≥ Three	5.9		
Sibship structure[b]			
Older brothers	0.3	0.5	2,000
Younger brothers	0.4	0.5	2,000
Older sisters	0.4	0.7	2,000
Younger sisters	0.2	0.5	2,000
Parents help with homework			1,985
Never	14.7		
Sometimes	49.7		
Often	35.6		

a. Scale of food frequency measures (see Table 3).
b. Mean number of each type of sibling.

simultaneous decisions on family nutritional environment and the schooling of a specific child.[2]

Specifically the GSCF asked mothers of sample children a series of questions adapted from a China Ministry of Health food frequency questionnaire. The basic instrument from which our food variety measure was derived was from these questions and adapted through pretesting for use in the Northwestern region of China. Via pretesting, we adapted wording to use terms familiar to residents of this region and dropped some items because of length. The survey instrument

asked about the frequency with which families consumed foods, including meat, aquatic food, rice, eggs, fresh vegetables, fresh fruits, dairy products, potatoes, grain, pickled vegetables, and baked or smoked foods, in the previous year.

To create a scale from this instrument, we undertook the following procedures: using principal components analysis of all 11 types of food,[3] we transformed a number of possibly correlated variables (consumption frequency of various foods, in this case) into a smaller number of uncorrelated variables called principal components (StataCorp 2000). This procedure revealed three principal components, or scales: one that identified meat, aquatic food, rice, eggs, fresh vegetables, fresh fruits and dairy products;[4] one that identified potatoes and grain; and one that identified pickled vegetables and baked or smoked foods.

The first scale identified types of foods that would likely be consumed in households with the money to supplement food that they produce themselves. In contrast, the second and third scales identified types of foods that could be grown or produced by the households. Substantively the first scale contains foods that are both protein rich and micronutrient rich, attributes that are considered most relevant with respect to impact on school-related outcomes (Levinger 1996; Pollitt 1997).

Technically the first food scale we constructed from these food items was also the best performing scale from the principal components analysis. Its eigenvalue was the highest and greater than one, and it was internally consistent, with a Cronbach's alpha of .87. In Appendix B we demonstrate how the food scale captures the consumption frequency of each type of food. It is clear that the higher score on the food scale, the greater the frequency with which component items are consumed. This pattern is consistent across all food items.

Moreover, for these eleven types of food, we found that consumption of potatoes and grains was negatively associated with family wealth, whereas consumption of other food items was positively associated with family wealth. This result is consistent with the interpretation that our food scale is differentiating households that are and are not able to supplement the foods that they can produce or purchase cheaply. Inclusion of other kinds of foods in our scale significantly reduces the internal consistency of the scale. We tested effects of these excluded food items on school outcomes and found none.

Table 3 presents the distributions of mothers' responses to the food frequency questions that were employed in the scale measure.

Household Expenditures

Our primary measure of household economic status, household expenditures in the previous year, was constructed from summing the major expenditures in the household.[5] These include school-related expenditures, medical expenditures, food expenditures, and other expenditures such as rent for land, daily consumption and service fees, expenditures on building and renovating houses, and so on. The mean value for annual household expenditures in our sample is 11,629 Chinese Yuan (about U.S.$1,401 based on the current exchange rate of U.S.$1 to 8.3 Chinese Yuan), and the log value is 9.2 (see Table 2).

TABLE 3

Sample Percent Distributions for Component Categories of Food Consumption for the Nutritional Environment Measure

	Meat	*Aquatic Products*	*Rice*	*Eggs*	*Fresh Vegetables*	*Fresh Fruit*		*Dairy Products*
Never	3.80	64.95	8.10	14.90	2.30	4.30	Never[a]	74.75
Less than one time a month	26.90	22.70	15.15	14.70	5.90	14.75	One cup a week	7.65
One to three times a month	30.35	6.70	25.15	16.55	12.25	15.90	Two to three cups a week	5.25
Once a week	13.90	2.60	22.20	12.55	12.15	14.05	Four to five cups a week	2.05
Two to three times a week	14.15	1.40	21.10	17.40	21.50	11.65	One cup a day	8.10
Four to five times a week	3.30	0.80	3.65	5.90	11.30	32.80	Two cups a day	1.25
Once a day	6.95	0.75	4.25	17.45	24.40	5.55	Three or more cups a day	0.90
Twice or more a day	0.65	0.10	0.40	0.50	10.20	0.95	—	—
Missing	0.00	0.00	0.05	0.05	0.00	0.05	Missing	0.05
Total	100.00	100.00	100.00	100.00	100.00	100.00	Total	100.00

Note: Wording for questions was "In the past year, how often did your family eat (food type)?"

Mother's Education

Parental human capital, or parental education, is typically an essential element of sociological models of school achievement. In less developed settings, maternal education is often thought to be more relevant for children's upbringing than paternal education. Mother's years of schooling is the measure we employ here.[6] Table 2 shows that the sample children's mothers' educational attainments were low: 29.8 percent of the 2,000 mothers were illiterate, about 43.6 percent had received one to six years of education, 22.6 percent had middle-school attainments (seven to nine years of education), and only 4.1 percent receive ten or more years of education (see Table 2).

Children's Characteristics

Gender and age. We also control for gender and age. In our sample of 2,000 children, 53.9 percent are boys and 46.1 percent are girls. The mean age of these children is eleven, and the sample children's ages range from nine to twelve (see Table 2).

Other Control Variables

Sibship Size and Structure. Sibship size and structure often have significant implications for children's schooling. Particularly in areas where son preference, poverty,

or both prevail, competition among siblings for resources may exist. Thus the presence of siblings may detract from school performance. Among the 2,000 children in our analytic sample, only 7.2 percent do not have siblings, whereas the percentages of those with one sibling reached 61.6 percent, and those with two siblings reached 25.4 percent. Children with three or more siblings account for 5.9 percent of the total (see Table 2). We consider not only sibship size but also the structure of the sibship: numbers of older and younger brothers and sisters.

Cultural Resources in the Home. Cultural resources in the home are an important element of the resources that support children's schooling. Cultural resources are often correlated with economic circumstances and human capital of the household but may independently affect children's schooling. Here, as a measure of the cultural environment in the home, we control for the number of books a household bought in the past year, including textbooks and other books. In GSCF sample households, the mean number is 21.5, but the range is large, from 0 to 99 (Table 2).

Social Resources in the Home. Like the cultural environment in the home, social resources are likely to be linked to family human capital and economic resources but measure a different dimension of the support children receive in the home. An important measure of social capital in the home is access to parental help with homework (see Coleman 1988).[7] We measure social resources in the home as mother's report of whether parents help children with homework. In rural Gansu, 35.6 percent of mothers report that parents often help with their children's homework, 49.7 percent report that parents sometimes help, and 14.7 percent report that parents never help (see Table 2).

Models

The models in this study all employ linear regression estimates. Our general strategy is as follows: we first show that poorer children are more likely to have inadequate access to nutritious foods by regressing our nutrition measure on the household economic resources measure. We then run standard sociological models of school performance, containing family socioeconomic background, children's characteristics, sibship size and composition, and family social and cultural resources. Then, to address our main questions, we add the family nutritional environment measure in subsequent models. With this process, the role of family nutritional environment in relation to other factors, particularly household expenditures, can be clearly demonstrated.

Another issue we deal with is the potential bias associated with unobserved school and community factors. It is reasonable to suspect that some of the observed family effects on school achievement could be biased without attention to aspects of schools or communities that might be correlated with some of the analytic variables. For example, families with high levels of wealth and human capital may be more likely to live in communities with schools that have better material and human resources. Although school effects are not the focus of this article, we do

TABLE 4

Regression Analysis of Nutritional Environment on Household Economic Status

	Nutritional Environment	*Nutritional Environment*	*Nutritional Environment*
Log expenditures	0.723	0.648	0.622
	(0.04)***	(0.04)***	(0.04)***
Mother's education		0.070	0.068
		(0.01)***	(0.01)***
School/village fixed effects			X
Constant	–3.245	–2.841	–2.596
	(0.39)***	(0.38)***	(0.38)***
R^2 (%)	12.69	18.54	21.24
Observations	2000	2000	2000

Note: Standard errors in parentheses.
*p < .05, **p < .01, ***p < .001 (two-tailed test).

need to address these kinds of problems to be confident of our results. For this reason, we re-estimate all models with school fixed effects. Because the majority of children are enrolled in elementary school and because there is generally one primary school per village, this strategy also addresses cross-village differences.

RESULTS

Nutritional Environment Regressions

Table 4 regresses family nutritional environment on household expenditures and other characteristics to demonstrate how economic deprivation is linked to family nutritional environment. These models show that poorer children and children with less educated mothers have significantly reduced access to various nutritious foods, even net of school and community effects. Indeed, about 13 percent of the variation in the nutritional environment scale can be accounted for in the model specification that includes expenditures alone. This finding suggests that poor children are particularly vulnerable to risks of poor nutrition, which may curtail poor children's capacity to perform well at school.

Average Semester Score Regressions

We next present a set of baseline models that regress average semester scores on children's socioeconomic and demographic background characteristics (see Table 5a). Consistent with expectations, these models show positive effects of household expenditures on children's school achievement: poorer children perform worse in school than those from wealthier families. Furthermore, both mother's education

TABLE 5a

Regression Analysis of Average Semester Scores without Nutritional Environment: Language and Math

	Chinese Model 1	*Chinese Model 2*	*Chinese Model 3*	*Mathematics Model 1*	*Mathematics Model 2*	*Mathematics Model 3*
Log expenditures	2.665	2.289	2.371	2.749	2.402	2.584
	(0.59)***	(0.61)***	(0.61)***	(0.66)***	(0.67)***	(0.68)***
Mother's education		0.481	0.450		0.466	0.444
		(0.09)***	(0.09)***		(0.10)***	(0.10)***
Female		2.925	2.792		1.185	1.060
		(0.64)***	(0.64)***		(0.71)	(0.71)
Age of child		–0.668	–0.631		–0.752	–0.674
		(0.28)*	(0.28)*		(0.31)*	(0.32)*
Older brothers		–1.333	–1.287		–2.161	–2.133
		(0.73)	(0.73)		(0.81)**	(0.81)**
Younger brothers		–0.456	–0.488		–1.300	–1.369
		(0.73)	(0.72)		(0.80)	(0.80)
Older sisters		–0.084	–0.109		–0.378	–0.438
		(0.49)	(0.49)		(0.54)	(0.54)
Younger sisters		0.298	0.196		0.180	0.088
		(0.66)	(0.66)		(0.74)	(0.74)
Books in the home		0.046	0.040		0.057	0.051
		(0.02)*	(0.02)*		(0.02)**	(0.02)*
Parents help with homework[a]		0.627	0.861		0.777	0.941
		(0.92)	(0.92)		(1.02)	(1.02)
Parents help with homework[b]		1.134	1.434		1.132	1.303
		(0.97)	(0.97)		(1.08)	(1.08)
School/village fixed effects			X			X
Constant	47.928	54.218	53.182	48.610	56.830	54.493
	(5.48)***	(6.13)***	(6.21)***	(6.07)***	(6.79)***	(6.89)***
R^2 (%)	1.02	4.91	6.81	0.89	3.82	5.42
Observations	1,951	1,915	1,915	1,957	1,921	1,921

Note: Standard errors in parentheses.

a. Sometimes.

b. Often.

*$p < .05$, **$p < .01$, ***$p < .001$ (two-tailed test).

and books in the home positively affect children's school achievement, whereas age of child is negatively associated with test scores. It is interesting that some factors that matter for children's achievement differ for language and math. For example, girls perform significantly better than boys in language but not in math. In contrast, having older brothers in the home negatively predicts math but not language.

TABLE 5b

Regression Analysis of Average Semester Scores on Nutritional Environment: Language and Math

	Chinese Model 1	*Chinese Model 2*	*Chinese Model 3*	*Mathematics Model 1*	*Mathematics Model 2*	*Mathematics Model 3*
Nutritional environment	1.689 (0.29)***	0.953 (0.33)**	0.972 (0.33)**	1.880 (0.32)***	1.034 (0.36)**	1.159 (0.37)**
Log expenditures		1.695 (0.64)**	1.781 (0.64)**		1.755 (0.71)*	1.878 (0.71)**
Mother's education		0.429 (0.09)***	0.398 (0.09)***		0.409 (0.10)***	0.383 (0.10)***
Female		2.966 (0.64)***	2.835 (0.64)***		1.221 (0.71)	1.104 (0.70)
Age of child		–0.684 (0.28)*	–0.633 (0.28)*		–0.770 (0.31)*	–0.676 (0.31)*
Older brothers		–1.175 (0.73)	–1.141 (0.73)		–1.992 (0.81)*	–1.961 (0.81)*
Younger brothers		–0.235 (0.73)	–0.284 (0.72)		–1.058 (0.81)	–1.126 (0.81)
Older sisters		0.076 (0.49)	0.041 (0.49)		–0.212 (0.54)	–0.266 (0.54)
Younger sisters		0.426 (0.66)	0.325 (0.66)		0.320 (0.74)	0.243 (0.74)
Books in the home		0.042 (0.02)*	0.036 (0.02)		0.054 (0.02)*	0.047 (0.02)*
Parents help with homework[a]		0.495 (0.92)	0.712 (0.92)		0.633 (1.02)	0.761 (1.02)
Parents help with homework[b]		0.867 (0.97)	1.140 (0.98)		0.839 (1.08)	0.948 (1.08)
School/village fixed effects			X			X
Constant	66.711 (1.04)***	56.820 (6.18)***	55.538 (6.25)***	67.512 (1.15)***	59.683 (6.85)***	57.336 (6.94)***
R^2 (%)	1.69	5.33	7.23	1.71	4.22	5.91
Observations	1,951	1,915	1,915	1,957	1,921	1,921

Note: Standard errors in parentheses.

a. Sometimes.

b. Often.

*$p < .05$, **$p < .01$, ***$p < .001$ (two-tailed test).

Next, to illustrate the role of family nutritional environment in conditioning children's educational outcomes, we add the family nutritional environment measure and run another set of models in Table 5b. Table 5b shows that a significant nutritional environment effect exists in the most simple specifications of the language and math models and holds in the models that control for household expenditures, other factors, and school fixed effects. The effect of

nutritional environment on math scores, for example, becomes stronger in the most conservative school fixed effects model. In the fixed effects model, each one-point increase along the eight-point nutrition measure scale is associated with a 1.16-point increase in math scores at the .01 level of significance. Table 5b also shows similarly significant effects of nutritional environment on language scores. These results suggest that family nutritional environment, as a factor traditionally outside the realm of "resource framework" for studying child development, does play a significant role in conditioning academic achievement, even net of other household and individual characteristics and school effects.

To address our second question, whether family nutritional environment is a mechanism of social reproduction, requires a different comparison, between the household expenditures effects in the models with and without the nutrition measure included (see Tables 5a and 5b). Comparing Table 5b to Table 5a, with the addition of nutritional environment, the effects of household expenditures get smaller and less significant in both math and language models. For instance, coefficients for household expenditure decrease from 2.58 to 1.88 in the math school fixed effects model. This result suggests that nutritional environment is one but not the only significant underlying mechanism by which economic resource constraints operate on school performance. As in Table 5a, school effects contribute to the model with nutritional environment in Table 5b, but they do not change the basic conclusions of our analysis.[8] The fact that the effects of household expenditures become less significant but do not disappear when the nutritional environment measure is included suggests that nutritional environment is not simply a proxy for economic welfare.

Results of regression models of average semester scores are consistent with our hypotheses about the role of family nutritional environment in conditioning children's school performance. Family nutritional environment exerts not only significant but also independent effects on children's schooling, net of effects of other home conditions and individual factors.

Finally, we note that although our nutrition results for models of average semester scores are consistently significant, the *R*-squares for the models are small. This finding is not unexpected, because these scores are based on assessments by individual teachers, analogous to grades. Thus, they are probably linked to many factors such as characteristics of particular teachers, classrooms, and grade levels that we do not control here. We next turn to an analysis of standardized curriculum-based language and math tests, which do not have this problem.

Standardized Test Regressions

Results for standardized test regressions are shown in Table 6. To focus on the question of interest in this study, Table 6 only presents coefficients for household expenditures, nutritional environment, and average semester scores. Other variables used in the models are the same as in the average semester test models and are listed in table notes. Because separate tests were given to children in

TABLE 6

Regression Analysis of Curriculum-Based Standardized Test Scores: Language and Math

	Grade 3 and Below				*Grade 4 and Above*			
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 1*	*Model 2*	*Model 3*	*Model 4*
Chinese								
Nutritional environment		6.945	5.357	5.164		0.939	1.376	0.677
		(0.96)***	(1.06)***	(1.05)***		(0.84)	(0.94)	(0.90)
Log expenditures	5.936		3.488	3.492	–1.245		–0.857	–2.059
	(1.85)***		(1.87)	(1.85)	(1.76)		(1.83)	(1.76)
Average semester Chinese				0.326				0.467
				(0.07)***				(0.08)***
R^2 (%)	13.09	8.31	16.93	20.14	9.31	0.29	9.80	18.03
Observations	568	581	568	562	415	421	415	407
Mathematics								
Nutritional environment		4.282	2.336	2.299		1.626	0.603	0.027
		(1.23)***	(1.35)	(1.33)		(0.99)	(1.18)	(1.15)
Log expenditures	5.856		4.495	3.846	2.069		1.532	0.451
	(2.60)*		(2.71)	(2.68)	(2.28)		(2.51)	(2.47)
Average semester				0.346				0.347
Mathematics				(0.08)***				(0.07)***
R^2 (%)	13.63	2.28	14.14	17.54	11.28	0.65	11.34	16.33
Observations	517	525	517	511	406	414	406	400

Note: Model 1 includes measures on mother's education, child's gender and age, number of each type of siblings, books in the home, parents help with homework, and school/village fixed effects; Model 2 includes nutritional environment only; Model 3 adds nutritional environment to Model 1; Model 4 adds average semester scores to Model 3. Standard errors in parentheses.

*$p < .05$, **$p < .01$, ***$p < .001$ (two-tailed test).

grades three and below and to children in grades four and above, we run the same set of models for children in grades three and below and in grades four and above.

In Model 1 we look at the effects of household expenditures on school performance while controlling for all background factors but not nutritional environment or average semester scores. Effects of nutritional environment on school performance are examined in Model 2 without controlling for any background factors. Model 3 regresses school performance on both nutritional environment and household expenditures, along with other background factors. Finally Model 4 adds average semester scores to Model 3. In these models, we are able to test a very conservative specification in which we control for prior performance (previous semester test scores) and thus focus on how nutrition predicts current performance. Not sure: Is it better to write as follows: This specification allows us to ask the question, does recent nutritional environment predict current achievement, net of any effects via past achievement?

Household expenditures show strong and positive impacts on both Chinese and math test scores in Model 1 but only among children in grades three and below. Similar to Table 5b, nutritional environment exerts significantly positive effects on both language and math scores in Model 2. However, like household expenditures, these effects do not show significance among children in grades four and above.

These results imply that young school children are vulnerable to the negative effects of economic deprivation and lack of access to nutritious food. In Model 3, the significant effects of nutritional environment hold for achievement in Chinese, which confirms the findings from previous models that used average semester scores. In the case of math achievement, the effects of nutritional environment are not significant when household expenditures and other background factors are controlled. The significance loss in the effects of nutritional environment on math suggests that the impact of nutritional environment on school performance may vary by subject. Our results from Model 4, in which we control for prior performance, do not change significantly from Model 3. Both models suggest that nutritional environment may influence school achievement more strongly among young children and in language tests.

Summing up results for the average semester tests and curriculum-based standard tests, we conclude that favorable nutritional environment in the home significantly predicts student math and language average semester scores and predicts current achievement on standardized language tests for young children, even net of average semester scores. For this younger group of children, about 8 percent of the variation in language achievement can be accounted for in the model that contains the nutrition measure alone; about 20 percent of the variation can be accounted for in the fixed effects model with nutrition, all background characteristics, and average semester scores (see Table 6). Moreover, the weakened household expenditures effects with the addition of food measures in the models provide evidence consistent with the mediating role of home nutritional environment.

DISCUSSION

This analysis has investigated the implications of family nutritional environment for children's school performance. In short, we have shown that nutritional environment in the home is associated with household socioeconomic status, that it predicts children's school performance, and that it is a significant mediator of poverty effects on schooling for children in early primary grades.

We find that poorer children are more likely to live in households with inferior nutritional environments and poorer children are less likely to perform well in school. More to the point, our analysis indicates that family nutritional environment itself exerts significant effects on children's school performance, and it works as a mechanism of economic disadvantage.

Moreover, in the models using curriculum-based standard tests, our results suggest that the effects of family nutritional environment on test scores may vary by subject. The nutritional environment measure does not affect children's math scores significantly net of background characteristics and average semester scores, but it strongly conditions young children's language scores. We do not have a ready explanation for the stronger results for language than math, although we note that the relationship between nutritional measures and academic achievement has also been found to vary by subject in previous studies (Florencio 1995). Further research is needed to clarify the difference in results for language and math.

Finally effects of important factors on curriculum-based standard tests vary with grade level. Household expenditures and nutritional environment both exert significant effects on test scores among children in lower grades only. Among children in higher grades, neither of these two factors is a significant predictor in any specification. Together with earlier evidence (Florencio 1995), these results suggest that young children may be more affected by nutritional deprivation, implying that the early transition into schooling is a critical time for child nutrition.

CONCLUSIONS

The analyses presented here have found support for the hypothesis that a favorable family nutritional environment is positively linked to children's school performance, net of family human capital, material, social, and cultural resources in the home, and school and community factors. We also found evidence to suggest that family nutritional environment works as a mechanism by which economic status affects school performance. In short, limited access to food in the home appears to be a significant dimension of the experience of poverty for children in rural China, and one that has important educational implications.

Poor access to nutritious foods is a key dimension of poverty in poor rural areas of China and in other countries as well. Similar or worse nutritional conditions prevail among children in many other developing countries. According to a review of figures in Park and Wang (2001:395), stunting rates in 1995 in China were about 39.1 percent (before dropping to 22 percent in 1998). Comparable 1995

figures for developing regions were 36 percent for all developing countries, 36.5 percent in Africa, 38.8 percent in Asia, and 12.6 percent in Latin America.

We suggest that poor access to nutritious foods experienced by children in these kinds of settings may be a significant way that household poverty places them at risk of low school performance. A concrete implication of this work is that designers of educational development initiatives in poor areas of China, and probably poor areas in other developing countries, should consider the possibility of incorporating nutrition components as supports.

It is interesting that the role of nutritional environment in conditioning educational opportunity and inequality may also extend beyond less developed settings where chronic malnutrition is a problem. The few available studies of nutrition and schooling in the United States have emphasized food security as a significant element of the family context of schooling. For example, a report by the American Dietetic Association (ADA 2002:1843) indicates that in 2000, 18 percent of children in the United States lived in food-insecure households. Studies suggest that food insecurity can adversely affect attention, interest, and learning, even when it is not linked to physical size measures, such as height, weight, or body mass index (ADA 2002; Levinger 1996; Winicki and Jemison 2003). For example, using an eighteen-item food security module in the Early Childhood Longitudinal Survey, Winicki and Jemison (2003) demonstrate significant negative effects on math achievement and on growth in math achievement among kindergarteners in households with even the most marginal levels of food deprivation. Similarly, a study using the Third Annual Health and Nutrition Examination Survey showed that six- to eleven-year-old food insecure children had significantly lower math scores, significantly more grade repetition, and significantly more behavioral problems (Alaimo, Olson, and Frongillo 2001).

Nutrition has been little considered in sociological research, and its possible role as a mechanism of poverty effects on schooling outcomes has not been considered at all. Complementing research in economics that has documented the impact of children's nutritional status on schooling outcomes, our findings indicate that the nutritional environment in the home is probably an important element of educational stratification in resource-constrained, developing country settings. The few available studies in the United States suggest that the concept is relevant in the domestic context as well. We propose that sociologists seeking to understand educational stratification should consider family nutritional environment, along with the economic, cultural, and social dimensions of home environment traditionally linked to school outcomes.

Acknowledgments: Data collection for the Gansu Survey of Children and Families was supported by The Spencer Foundation Small and Major Grants Programs, by National Institute of Health Grants 1R01TW005930-01 and 5R01TW005930-02, and by a grant from the World Bank. Earlier versions of this article were presented at the 2003 annual meeting of the Population Association of America (May 1-3, Minneapolis, Minnesota) and the 2003 Meeting of the International Health Economics Association (June 15-18, San Francisco, California). The authors would like to thank Grace Kao, Elizabeth Cooksey, Jed Friedman, and Jere Behrman for helpful comments.

APPENDIX A

Description of China Health and Nutrition Survey (CHNS) data extract used in Table 1

The data used in Table 1 come from the CHNS. This survey covers eight provinces—Guangxi, Guizhou, Henan, Hubei, Hunan, Jiangsu, Liaoning, and Shandong—that vary substantially in geography, economic development, public resources, and health indicators. The analysis included children ages seven to twelve in 1993 and who had ever enrolled in primary school, with a maximum sample size of 1,206 for analyses. We regressed grades behind in 1993 on nutritional status and other characteristics of children and their households in 1989. Measures included in the models are described below.

School Performance

In the CHNS household survey, the years of formal education and age were collected for each member in the selected households. Like in Jamison's (1986) study, grades behind is simply the grade a child should be in, given age minus actual grade. The widely used seven-years-old for entering Grade 1 criteria in China is used as a standard to measure grades behind.

Nutritional Status

Children received detailed physical examinations in CHNS survey that included weight and height. Height is measured as centimeters in the survey, and in this analysis, we construct height-for-age using height, age, and sex for the purpose of standardization. Height-for-age is expressed as percent of the median value for a large sample of U.S. children of the same age and sex surveyed by the U.S. National Center for Health Statistics (NCHS), referred to as the NCHS standard. Similarly, weight-for-age is constructed in the same way as another indicator of children's nutritional status.

Control Variables

In this analysis, we use per capita income as an indicator of family wealth. Income was constructed by summing all sources, including wages, home gardening, farming, raising livestock, fishing, small business, and so forth. As a measure of parental human capital, we used mother's and father's years of schooling. We also control for gender and age. Sibship size and structure often have significant implications for children's schooling. In this study, we include the siblings in the age range of seven to twelve, assuming the presence of these siblings would probably affect the index child's schooling the most. Urban-rural and regional differences in living standards and public resources in China are significant and increasing with rapid economic development; we thus control for urban-rural residence and province of residence.

APPENDIX B

Sample Percent Distributions for Component Categories of Food Consumption for the Nutritional Environment Measure

	Meat		*Aquatic Products*		*Rice*		*Eggs*		*Fresh Vegetables*		*Fresh Fruit*	
	Low[a]	*High*[a]	*Low*	*High*	*Low*	*High*	*Low*	*High*	*Low*	*High*	*Low*	*High*
Never	14.1	0.3	93.6	16.3	31.8	1.3	50.2	0.0	12.2	0.0	19.3	0.0
Less than one time a month	47.4	4.1	4.9	48.4	36.4	0.9	33.0	0.6	27.5	0.0	45.0	0.3
One to three times a month	28.1	18.4	1.5	14.7	23.9	10.6	11.9	1.9	32.4	0.0	24.5	1.6
Once a week	4.9	23.4	0.0	7.5	6.7	26.6	3.1	4.1	13.8	3.8	8.3	5.9
Two to three times a week	4.3	22.8	0.0	5.0	1.2	40.0	1.5	16.6	10.4	8.4	2.5	10.3
Four to five times a week	0.3	9.1	0.0	3.4	0.0	9.1	0.0	16.3	2.5	9.4	0.6	60.3
Once a day	0.9	19.4	0.0	4.1	0.0	10.3	0.3	57.5	1.2	50.3	0.0	18.4
Twice or more a day	0.0	2.5	0.0	0.6	0.0	1.3	0.0	2.8	0.0	28.1	0.0	3.1
Missing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Total	100	100	100	100	100	100	100	100	100	100	100	100

	Dairy Products	
	Low	*High*
Never	99.1	26.3
One cup per week	0.6	8.1
Two to three cups per week	0.0	13.8
Four to five cups per week	0.0	7.2
One cup a day	0.0	35.0
Two cups a day	0.0	5.0
Three or more cups a day	0.0	4.7
Missing	0.3	0.0
Total	100	100

a. A "low" score on the nutritional environment scale means the score is one standard deviation lower than the mean score. A "high" score on the nutritional environment scale means the score is one standard deviation above the mean score.

NOTES

1. This replication, and related analysis of the CHNS data, are discussed in further detail in Yu and Hannum (2006).
2. One underlying assumption in our measure of home nutritional environment is that within families, food is equally available to all household members, especially children. The results could be problematic if this is not the case. Previous research indicates that birth order and gender may affect intrahousehold allocations on resources such as nutrient intake (Behrman 1988; Rosenzweig and Schultz 1982). Higher order children or boys are relatively favored in intrafamily resource distribution compared to lower order children and girls.

   The GSCF does not contain measures on food consumption at the individual level. However, sex and sibship structure are both included in the models that investigate the effect of home nutritional environment on school performance. These inclusions will reduce the bias, if any, on the estimates of home nutritional environment resulting from unequal allocations along sex and birth order by controlling for sex and sibship structure. On the other hand, it is reasonable to argue that the effect of older brothers and the effect of sex (female in the models) on school performance in this analysis are overestimated and underestimated, respectively, in the presence of unequal allocations, if any, on food consumption.

   Furthermore, although there is some promale and pro-adult bias in terms of food consumption, evidence of this intrahousehold inequality is scarce outside of northern India and Bangladesh (Haddad et al. 1996).
3. Principal components analysis analyzes the total variance of correlated variables included in the analysis (Ingram 1998; StataCorp 2000). The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible (StataCorp 2000). The number of factors (principal components) that should be extracted depends on Eigenvalues. Kaiser's "Eigenvalue greater than one" criterion is widely used as a cutoff for determining the number of factors to be retained (Krus 1998). The scale employed here was the factor that had a highest Eigenvalue and the Eigenvalue is greater than one.
4. We note that for the questions about dairy products, our instrument failed to include a category that would capture people who did consume dairy products but consumed less than one cup a week. Based on the item refusal rate of .05 percent, which was consistent with that for some of the other nutrition questions, we assume that people who fell in this category fit themselves into the more appropriate of the "never" or "one cup a week" categories. Although this problem prevents us from knowing the exact consumption patterns of people at the low end of the spectrum, we think that it should not affect the ordering of the categories.
5. We chose to employ household expenditures, rather than income, as our measure of economic status. In research in developing societies, expenditures are usually considered to be a better measure of both current and long-term welfare. As families tend to smooth consumption over time, household expenditures usually vary less from year to year than incomes (Park and Wang 2001:393). Another commonly used measure of socioeconomic status in less developed settings is wealth. We compared the results using expenditures and wealth and found that both variables provided consistent results. However, expenditures were more strongly linked to school performance.
6. Father's education was also included in earlier analyses but was dropped because of failure to achieve significance in models that also controlled for mother's education.

7. Indicators based on family networks are also commonly used as measures of family social capital. We chose not to employ these measures, as other analyses have suggested that commonly used indicators of embeddedness into friendship networks do not transfer well to rural China (Hannum and Park 2002).
8. To be able to argue that current household nutritional environment, rather than long-run nutritional status, exerts important effects on children's school performance, we also explore the possibility that early childhood nutrition may be correlated with the nutrition measures in this study and therefore weaken our argument. We included child birth weight (as mother reported in the survey) as one indicator of early childhood nutrition, along with home nutrition environment measures and other control variables in the model (not shown in the tables), and found that early childhood nutrition did not impose any significant impact on children's school performance. On the other hand, the effects of home nutritional environment on school performance remain unchanged with the inclusion of the birth weight measure.

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