Online Appendix
Food for thought? Experimental Evidence on the Learning Impacts of a Large-Scale School Feeding Program

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Online Appendix A1. Literature review on the effects of school feeding on child learning

Table A.1 presents an overview of all school feeding experiments that we are aware of in low- and middle-income countries (LMICs). Notably, none of those studies evaluate government programs. Further, most of them evaluated effects on child nutrition outcomes, and to a lesser extent, cognition, while fewer studies have assessed effects on educational outcomes. Within the latter set, the vast majority evaluated impacts on schooling, with a consistent positive effect of school feeding programs on school enrolment and attendance, although with variation in effect sizes (Alderman and Bundy 2012; Drake et al. 2017). By contrast, fewer experiments have provided evidence on the impacts of school feeding on learning. Finally, last column of Table A.1 shows that heterogeneity analysis by child and household characteristics such as gender or poverty status is also limited. Most studies that assess heterogeneity focus on initial nutritional status. as they are small-scale efficacy trials of nutritionally-fortified meals, snacks or beverage administered at school.

The remainder of this section presents more detailed evidence from school feeding trials that focus on learning outcomes in both primary and preprimary schools in LMICs and discusses reasons for variation in treatment effects. For a meta-analysis of learning effects combining different school feeding interventions, see Snilstveit et al. (2015).

With regards to Sub-Saharan Africa, after one year of implementation, a field experiment evaluating different implementation modalities of the World Food Programme school feeding program in primary schools in internally-displaced people camps in Northern Uganda showed that the school feeding increased math for girls only (Alderman, Gilligan, and Lehrer 2012). A two-year randomized trial set in

12 schools in one rural district in Kenya focusing on providing meat, milk, and an “energy” meal to 360 primary school-children as a mid-morning snack, documented improved arithmetic test scores for children in the meat and milk groups (Neumann et al. 2007; Hulett et al. 2014; Whaley et al. 2003). Another study conducted in two districts in Western Kenya documented that a preschool breakfast program run by a Dutch NGO increases in preschoolers’ curricula test scores, but only for those children attending more often and that had a more experienced teacher (Vermeersch and Kremer 2005).

In Central and Southern America, a randomized trial in 16 rural Jamaican schools showed that primary school children receiving a school breakfast increased their math achievements, and effects were stronger among undernourished children (Grantham-McGregor, Chang, and Walker 1998; Powell et al. 1998). In rural Peru, a breakfast program improved performance on a vocabulary assessment among heavier children (Jacoby, Cueto, and Pollitt 1996).

With regards to Asian countries, recently, two trials have used the infrastructure of the Indian school feeding program to scale up food fortification, with no average effects on learning (Berry et al. 2018; Krämer, Kumar, and Vollmer 2018). However, Krämer et al. found positive treatment effects of about 0.2 standard deviations on math and reading for pupils who had more than 80 or 90 percent school-attendance. In Bangladesh, Ahmed (2004) evaluated the impact of mid-morning snack consisting of eight fortified wheat biscuits to around one million children in approximately 6,000 primary schools in highly food-insecure rural areas, plus four slum areas in Dhaka City, which was implemented by the World Food Programme. The snack improved test scores by 15.7 percent points, with larger effects on math. Students from urban slums did better in achievement tests than students from rural areas, probably due to better quality urban schools. Finally, in urban central Jakarta, Indonesia, 384 children across six schools were randomly assigned to different intervention groups related to administration of: (i) micronutrients; (ii) fatty acids; (iii) both; (iv) control. No effects on reading comprehension were detected (Osendarp et al. 2007).

Mixed findings in existing literature can be attributed, on the one hand, to differences in study methodologies and in target populations (e.g. child age, rural vs. urban, etc.), as well in variation in program implementation (e.g. modality of feeding, type of foods administered, quality and length of program implementation, etc.). On the other, school meals might not be enough to raise schooling achievements in settings where complementary educational inputs such as teachers or infrastructure are lacking or are of poor quality. Also, the offer of the meal can increase enrolment and, if educational inputs are fixed, the quality of overall learning inputs may decrease. Similarly, the offer of school meals may have composition effects and peer effects by attracting new students that are of often of less advantaged backgrounds and that tend to have lower achievements when entering school. Additionally, in contexts where food insecurity is especially high, the transfer might not be able to offset the opportunity costs of child labor. Further, households may redistribute food away from the child receiving school meals, potentially offsetting their nutritional benefits. Finally, school meals may not be effective in raising learning outcomes for fairly well-nourished populations. While this last hypothesis may be less salient in LMICs (though the Peruvian trial mentioned above may demonstrate otherwise), evidence from Australia, United Kingdom or the United States show that school feeding can improve learning achievements even among population were undernutrition is less of a policy concern (Osendarp et al. 2007; Belot and James 2011; Figlio and Winicki 2005).

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Table A.1.

Summary characteristics of existing randomized control trials of school feeding in low- and middle-income countries

	Study	Location	Duration	Treatment	Implementer	Geographical area	Outcomes	Heterogeneity analysis by child or household backgrounds
1	Ahmed (2004)	Bangladesh	14 months	Snack	WFP and partner NGOs	9 districts	Schooling; learning; nutrition	-
2	Alderman et al., (2012)	Refugee camps in Northern Uganda	28 months	School feeding or take-home rations	WFP	10 refugee camps	Schooling	Age Gender
3	Andang'o et al. (2007)	Kenya	5 months	Fortified maize	Researchers	4 schools	Nutrition	-
4	Ash et al., (2003)	Tanzania	6 months	Fortified beverages	Researchers	6 primary schools	Nutrition	Initial nutritional status
5	Berry et al. (2018)	Odisha (India)	3 years	Micronutrient supplementation in existing program	Researchers	1 district	Nutrition	Initial nutritional status

6	Grantham-McGregor et al., (1998)	Jamaica	21 weeks	Breakfast	Researchers	4 rural primary schools	Cognition	Initial nutritional status
7	Kazianga et al., (2012)	Northern Burkina Faso	1 year	School feeding or take-home rations	WFP	46 schools	Schooling; labor	Gender
8	Kramer et al. (2018)	Bihar (India)	1 year	Micronutrient supplementation in existing program	Researchers	Two blocks of Jenahabad district	Nutrition; cognition; learning	-
9	Jacoby et al. (1996)	Peru	3 months	Breakfast	Researchers	Ten schools	Nutrition; schooling; learning	Initial nutritional status
10	Moretti et al. (2006)	Bangalore (India)	9 months	Fortified rice	Researchers	1 school	Nutrition	-
11	Muthayya et al., (2007)	Urban Bangalore, India`	1 year	Snack	Researchers	69 children	Cognition	-
12	Osendarp et al., (2007)	Urban Jakarta, Indonesia	1 year	Snack	Researchers	6 schools	Nutrition; cognition; learning	-
13	Radhika et al. (2011)	Andhra Pradesh (India)	8 months	Fortified rice	Researchers	1 school	Nutrition	-

14	van Stuijvenberg et al., (1999)	South Africa	1 year	Snack and beverage	Researchers	1 school	Nutrition; cognition; schooling; morbidity	-
15	Vermeersch and Kremer (2005)	Western Kenya	2 years	Breakfast	NGO	25 schools in 2 districts	Learning	Gender
16	Whaley et al., (2003); Hulett et al. (2014); Neumann et al. (2007)	Kenya	21 months	School feeding	Researchers	12 schools	Learning	-
17	Zimmermann et al. (2003)	Morocco	9 months	Fortified salt	Researchers	2 schools	Nutrition	-

Notes: the table above provides characteristics in terms of implementer, duration, program type, geographical areas and outcomes analyzed of existing randomized trials of school feeding. Studies were first identified through the systematic review conducted in 2012 by Lawson (Lawson 2012), which the authors had updated. WFP: World Food Programme.

Online Appendix 1.

Balance of outcomes and child and household characteristics between sample communities and communities excluded after the baseline due to the discovery of school feeding

	Longitudinal Sample		**Community dropped after baseline**		**Difference**
	N	**Mean/SE**	**N**	**Mean/SE**	**(1)-(2)**
Math	4507	2.523	1295	2.361	0.162*
		[0.042]		[0.076]	
Literacy	4507	3.103	1295	2.843	0.259**
		[0.056]		[0.097]	
Age in years	4800	9.643	1376	9.530	0.113
		[0.044]		[0.082]	
Male	4800	0.518	1376	0.520	-0.002
		[0.007]		[0.013]	
Enrolled	4517	0.980	1266	0.987	-0.007
		[0.002]		[0.003]	
Private school	4780	0.105	1362	0.057	0.048***
		[0.004]		[0.006]	
Repeated grade	4160	0.143	1186	0.138	0.005
		[0.005]		[0.010]	
Absent previous school week	4251	0.148	1217	0.065	0.083***
		[0.011]		[0.013]	
Height-for-age z-scores	4338	-1.105	1271	-1.073	-0.032
		[0.020]		[0.037]	
Sick in previous week	4564	0.090	1318	0.086	0.004
		[0.004]		[0.008]	
Number of target age children in the household (5-15 years)	4800	3.357	1376	3.480	-0.123**
		[0.025]		[0.049]	
Number of under 5 years old	4800	0.938	1376	0.922	0.017
		[0.014]		[0.025]	
Household size	4800	6.757	1376	6.871	-0.114
		[0.041]		[0.079]	
Head of the household is male	4800	0.798	1376	0.836	-0.038***
		[0.006]		[0.010]	
Household owns livestock	4800	0.656	1376	0.728	-0.072***
		[0.007]		[0.012]	
Mother's age	4621	38.999	1309	38.506	0.494
		[0.164]		[0.297]	

Mother's education	2078	6.038	463	6.201	-0.162
		[0.100]		[0.227]	
Wealth index	4363	13.925	1241	13.284	0.641*
		[0.183]		[0.316]	
Sold agriculture produce in the past year	4800	0.463	1376	0.423	0.040***
		[0.007]		[0.013]	
Per capita expenditure	4800	2065.831	1376	1886.849	178.982***
		[15.110]		[28.530]	
Urban	4796	0.064	1376	0.033	0.031***
		[0.004]		[0.005]	
Northern regions	4800	0.448	1376	0.710	-0.263***
		[0.007]		[0.012]	
Head of the household's age	4772	45.696	1372	46.255	-0.560
		[0.180]		[0.362]	
Treatment	4724	0.545	615	0.080	0.465***
		[0.007]		[0.011]	

Notes: Columns 1-2 test whether there were differences between sample communities and communities that were dropped after baseline due to discovery of presence of school feeding.

Online Appendix 2.

Balance of selected child and household characteristics at baseline (Panel A) and endline (Panel B) for the longitudinal sample, all children and stratified by gender, household poverty and northern regions

Panel A. Balance of baseline characteristics for longitudinal sample

	Child age in months	Male	House-hold size	Head of the house-hold is male	Mother's age	Wealth index	Has sold any produce in the past year	Livestock
All children								
School feeding	1.002	-0.026	-0.159	-0.003	1.092	0.206	-0.067	-0.015
	(1.491)	(0.019)	(0.315)	(0.041)	(0.730)	(1.554)	(0.055)	(0.048)
Constant	102.756***	0.535***	6.776***	0.806***	37.365***	13.219***	0.508***	0.676***
	(1.140)	(0.014)	(0.237)	(0.031)	(0.545)	(1.108)	(0.039)	(0.033)
Observations	3,170	3,170	3,170	3,170	3,052	2,902	3,170	3,170
R-squared	0.000	0.001	0.001	0.000	0.003	0.000	0.005	0.000
Girls								
School feeding	1.079	0.000	-0.161	0.040	1.059	0.461	-0.074	0.004
	(1.669)	(0.000)	(0.320)	(0.046)	(0.894)	(1.685)	(0.055)	(0.053)
Constant	101.259***	0.000	6.612***	0.768***	37.848***	13.156***	0.507***	0.648***
	(1.232)	(0.000)	(0.246)	(0.037)	(0.751)	(1.134)	(0.040)	(0.037)
Observations	1,517	1,517	1,517	1,517	1,461	1,387	1,517	1,517
R-squared	0.000		0.001	0.002	0.002	0.000	0.005	0.000
Below poverty line								
School feeding	5.087**	-0.017	-0.089	-0.056	0.869	0.465	-0.018	0.027
	(2.547)	(0.037)	(0.535)	(0.047)	(1.442)	(0.910)	(0.082)	(0.061)
Constant	101.072***	0.530***	7.046***	0.872***	38.535***	8.028***	0.542***	0.742***
	(1.820)	(0.030)	(0.367)	(0.030)	(1.140)	(0.714)	(0.055)	(0.047)
Observations	721	721	721	721	708	665	721	721
R-squared	0.007	0.000	0.000	0.006	0.001	0.002	0.000	0.001
Northern regions								
School feeding	-0.323	-0.023	-0.122	-0.044	1.476	0.860	-0.078	-0.026
	(2.459)	(0.025)	(0.479)	(0.032)	(0.918)	(1.644)	(0.088)	(0.064)
Constant	102.577***	0.552***	7.202***	0.940***	36.093***	9.591***	0.498***	0.770***
	(2.031)	(0.017)	(0.341)	(0.020)	(0.623)	(1.242)	(0.066)	(0.042)
Observations	1,462	1,462	1,462	1,462	1,414	1,360	1,462	1,462
R-squared	0.000	0.001	0.000	0.006	0.006	0.002	0.006	0.001

Panel B. Balance of endline characteristics for longitudinal sample								
	Child age in months	**Male**	**House-hold size**	**Head of the house-hold is male**	**Mother's age**	**Wealth index**	**Has sold any produce in the past year**	**Livestock**
	All children							
School feeding	1.644	-0.011	-0.151	-0.036	0.803	-0.763	-0.004	-0.029
	(1.425)	(0.020)	(0.338)	(0.038)	(0.786)	(3.252)	(0.054)	(0.040)
Constant	130.809***	0.540***	7.501***	0.821***	40.534***	30.070***	0.320***	0.748***
	(1.038)	(0.016)	(0.236)	(0.027)	(0.579)	(2.414)	(0.038)	(0.025)
Observations	2,542	2,573	3,170	3,168	3,014	3,168	3,167	3,167
R-squared	0.001	0.000	0.001	0.002	0.001	0.001	0.000	0.001
	Girls							
School feeding	0.734	0.000	-0.100	-0.006	1.332	-2.069	0.001	0.010
	(1.876)	(0.000)	(0.372)	(0.045)	(0.888)	(3.400)	(0.058)	(0.046)
Constant	129.561***	0.000	7.361***	0.804***	40.403***	30.857***	0.316***	0.727***
	(1.365)	(0.000)	(0.238)	(0.035)	(0.720)	(2.601)	(0.042)	(0.034)
Observations	1,179	1,198	1,198	1,198	1,158	1,198	1,197	1,197
R-squared	0.000		0.000	0.000	0.004	0.004	0.000	0.000
	Below poverty line							
School feeding	7.802***	0.030	-0.114	-0.084	-0.527	0.258	-0.005	-0.084
	(2.933)	(0.040)	(0.560)	(0.054)	(1.499)	(2.836)	(0.084)	(0.059)
Constant	128.869***	0.514***	7.800***	0.855***	42.006***	24.241***	0.351***	0.829***
	(2.122)	(0.029)	(0.390)	(0.034)	(1.116)	(2.023)	(0.055)	(0.041)
Observations	595	602	721	721	689	721	721	721
R-squared	0.016	0.001	0.000	0.011	0.001	0.000	0.000	0.011
	Northern regions							
School feeding	2.254	0.000	0.068	-0.054	1.161	2.095	-0.025	-0.016
	(2.040)	(0.026)	(0.552)	(0.044)	(1.040)	(1.512)	(0.076)	(0.042)
Constant	129.107***	0.541***	7.685***	0.901***	39.417***	16.090***	0.299***	0.830***
	(1.510)	(0.020)	(0.351)	(0.026)	(0.720)	(1.100)	(0.063)	(0.019)
Observations	1,208	1,222	1,462	1,462	1,410	1,462	1,462	1,462
R-squared	0.001	0.000	0.000	0.006	0.003	0.018	0.001	0.000

Notes: Panels A and B report balance in child and household baseline and endline covariates respectively, by treatment assignment for the full longitudinal sample and for the longitudinal sample stratified by gender, poverty status and northern regions. For each covariate, the coefficient for treatment was obtained through an OLS regression in which each covariate was the outcome and assignment to school feeding was the main regressor. Standard errors were clustered at the community level. The estimated school feeding coefficient provides the difference between the school feeding and control group in a child’s backgrounds and its standard errors for the full longitudinal sample, in order to ascertain whether there were systematic biases induced by attrition.

Online Appendix 3.

Predictors of endline program uptake in treatment communities

	(1)	(2)	(3)	(4)
Child age in months	-0.000	-0.001	-0.001	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
Child aged 5-11 years at baseline	0.170***	0.174***	0.173***	0.017
	(0.044)	(0.042)	(0.042)	(0.043)
Male	0.025	0.011	0.011	0.018
	(0.024)	(0.027)	(0.027)	(0.028)
Below poverty line	0.144***	0.108***	0.107***	0.026
	(0.035)	(0.032)	(0.032)	(0.029)
Northern regions	0.197**	0.175**	0.179**	0.006
	(0.077)	(0.072)	(0.075)	(0.066)
Math standardized scores at baseline		-0.050**	-0.049**	-0.024
		(0.023)	(0.023)	(0.016)
Literacy standardized scores at baseline		-0.093***	-0.092***	-0.026
		(0.024)	(0.024)	(0.017)
GSFP program (HGSF is baseline)			0.022	
			(0.075)	
Child is currently enrolled in primary school				0.294***
				(0.049)
Grade at baseline				0.007
				(0.013)
Private school				-0.638***
				(0.068)
Child's HAZ at baseline				-0.018*
				(0.010)
Child has fallen sick in the past week				-0.014
				(0.049)
Age of household head				-0.001
				(0.002)
Mother's age				-0.001
				(0.002)
Household size				0.006
				(0.005)
Household sold produce in the past year				0.043
				(0.035)
Wealth index				-0.006**
				(0.002)
Constant	0.423***	0.478***	0.465***	0.889***
	(0.119)	(0.115)	(0.122)	(0.144)
Observations	1,333	1,247	1,247	997
R-squared	0.077	0.118	0.118	0.415

Notes: This table presents results from linear probability models examining predictors of school feeding uptake at endline for children in the treatment arm. We regress uptake on a set of variables, including key predictors of heterogeneity (Col.1); baseline scores in the various competencies (col. 2); modality of school feeding (col.3) and child- and household-level characteristics. All models clustered the standard errors at the community level.

Online Appendix 4.

Balance of raw test scores for baseline sample prior to attrition

	Balance by treatment assignment and attrition			
	Math	**Literacy**	**Math**	**Literacy**
School feeding	0.073	0.106	0.141	0.049
	(0.146)	(0.211)	(0.252)	(0.282)
Child in longitudinal sample			0.265	0.342
			(0.177)	(0.228)
School feeding * Longitudinal sample			-0.070	0.068
			(0.273)	(0.303)
Constant	-1.492***	-1.304***	-1.734***	-1.618***
	(0.165)	(0.209)	(0.199)	(0.264)
Obs.	3,262	3,262	3,262	3,262
R-squared	0.204	0.144	0.205	0.146
Baseline control	1.54	1.78		
	(2.01)	(2.40)		
Baseline treatment	1.67	1.93		
	(2.05)	(2.51)		
Baseline control - lost to follow-up			1.13	1.28
			(1.51)	(1.88)
Baseline control - longitudinal sample			1.57	1.81
			(2.04)	(2.43)
Baseline treatment - lost to follow-up			1.68	1.97
			(2.07)	(2.56)
Baseline treatment - longitudinal sample			1.51	1.58
			(1.85)	(1.83)

Notes: *** p<0.01, ** p<0.05, * p<0.1. Columns 1-4 test whether there were differences in raw scores by treatment arm prior to attrition. This is achieved through an OLS regression in which each child test score at baseline is regressed on a treatment dummy. Columns 1-4 add a dummy if the child was in the longitudinal sample and an interaction between longitudinal sample and treatment in order to investigate survey attrition bias. All models include child age in months and standard errors are clustered at the community level. Raw test scores appeared balanced by treatment arm prior to attrition, and there is no evidence of differential attrition by treatment being associated with raw test scores.

Online Appendix 5.

Descriptive statistics of raw test scores at baseline and endline, by child gender, household poverty status, and Northern regions

	Panel A. Gender									
	Baseline					Endline				
	Girls		Boys			Girls		Boys		
	N	Mean/SE	N	Mean/SE	Difference	N	Mean/SE	N	Mean/SE	Difference
Math	1,433	1.585 [0.053]	1,580	1.675 [0.053]	-0.09	1,185	3.882 [0.101]	1,372	3.805 [0.090]	0.076
Literacy	1,433	1.884 [0.065]	1,580	1.903 [0.064]	-0.019	1,185	4.136 [0.102]	1,372	4.106 [0.097]	0.029
	Panel B. Poverty									
	Baseline					Endline				
	Non-Poor		Poor			Non-Poor		Poor		
	N	Mean/SE	N	Mean/SE	Difference	N	Mean/SE	N	Mean/SE	Difference
Math	2,324	1.66 [0.043]	688	1.541 [0.078]	0.12	1,953	3.906 [0.077]	604	3.631 [0.136]	0.275*
Literacy	2,324	1.974 [0.054]	688	1.626 [0.083]	0.348***	1,953	4.225 [0.082]	604	3.78 [0.136]	0.445***
	Panel C. Region of residence									
	Baseline					Endline				
	Southern regions		Northern regions			Southern regions		Northern regions		
	N	Mean/SE	N	Mean/SE	Difference	N	Mean/SE	N	Mean/SE	Difference
Math	1,626	1.918 [0.055]	1,387	1.298 [0.048]	0.620***	1,326	3.769 [0.089]	1,231	3.918 [0.102]	-0.149
Literacy	1,626	2.351 [0.069]	1,387	1.358 [0.053]	0.993***	1,326	4.241 [0.101]	1,231	3.99 [0.097]	0.250*

Notes: The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Household poverty is a dichotomous indicator having the value of one if the household had baseline per capita consumption levels falling below the national consumption poverty line in 2013. Northern regions include Upper West, Upper East, and Northern region. Southern regions include Western, Central, Greater Accra, Volta, Eastern, Asanti, Brong Ahafo.

Online Appendix 6.

Treatment effects of school feeding on child learning, by child age group at baseline

	Math	**Literacy**	**Composite: math and literacy**
Panel A. Children 5-11 years at baseline			
School feeding	0.161**	0.132*	0.177**
	(0.078)	(0.076)	(0.086)
Observations	2,011	2,006	2,045
R-squared	0.061	0.124	0.135
Panel B. Children 12-15 years at baseline			
School feeding	0.040	0.123	0.096
	(0.126)	(0.108)	(0.128)
Observations	267	268	269
R-squared	0.167	0.201	0.185

Notes: *** p<0.01, ** p<0.05, * p<0.1. The table above illustrates intent-to-treat effects on each outcome estimated through ANCOVA for different age cohorts. All models were estimated through OLS and standard errors in parentheses were clustered at the community level. For each outcome, the model controls for the baseline value of the outcome, and region dummies. Math and literacy scores are age-standardized. Composite indices were computed as averages of the standardized scores and then they were standardized to the control group within each round.

Online Appendix 7.

Heterogeneity in treatment effects by length of program exposure

	(1)	(2)	(3)
	Maths	**Literacy**	**Composite: math and literacy**
School feeding	-0.0110	-0.0393	-0.0242
	(0.147)	(0.153)	(0.167)
Two years of exposure	-0.0775	-0.166	-0.136
	(0.104)	(0.131)	(0.129)
School feeding * Two years of exposure	0.177	0.201	0.224
	(0.136)	(0.149)	(0.154)
Observations	2,278	2,276	2,290
R-squared	0.069	0.132	0.122

Notes: *** p<0.01, ** p<0.05, * p<0.1. The table above illustrates intent-to-treat effects on each outcome estimated through ANCOVA. Both models were estimated through OLS and standard errors in parentheses were clustered at the community level. For each outcome, the model controls for the baseline value of the outcome, and region dummies. Math and literacy scores are age-standardized. Composite indices were computed as averages of the standardized scores and then they were standardized to the control group within each round. Two years of exposure is a dummy equal to zero if the child was above below 5 years or was in grade 5 at baseline.

Online Appendix 8.

Descriptive statistics of intermediate outcomes, full sample

	Baseline					Endline				
	Control		School feeding			Control		School feeding		
	N	**Mean (SE)**	**N**	**Mean (SE)**	**Diff.**	**N**	**Mean (SE)**	**N**	**Mean (SE)**	**Diff.**
Child is enrolled	1,353	0.988	1,604	0.981	0.007	1,195	0.884	1,377	0.932	-0.049***
		[0.003]		[0.003]			[0.009]		[0.007]	
Days attended over past week	1,291	4.881	1,508	4.828	0.052**	1,056	4.665	1,284	4.685	-0.02
		[0.018]		[0.019]			[0.030]		[0.026]	
Grade	1,368	2.336	1,589	2.436	-0.100*	1,049	4.269	1,278	4.496	-0.227***
		[0.039]		[0.037]			[0.061]		[0.055]	
Digit span (raw)	1404	4.123	1579	4.365	-0.242***	1186	4.173	1343	4.381	-0.208**
		[0.059]		[0.056]			[0.072]		[0.068]	
SPM (raw)	1404	3.819	1579	3.967	-0.148	1186	2.993	1343	3.243	-0.249***
		[0.070]		[0.065]			[0.057]		[0.055]	
Digit span (age-standardized)	1398	-0.063	1565	0.011	-0.074**	1147	-0.035	1284	0.099	-0.134***
		[0.026]		[0.024]			[0.028]		[0.028]	
SPM (age-standardized)	1395	-0.065	1569	-0.010	-0.056	1150	-0.033	1288	0.119	-0.152***
		[0.026]		[0.024]			[0.029]		[0.028]	
Height-for-age z-scores	1354	-1.112	1540	-1.054	-0.058	1020	-1.211	1165	-1.123	-0.088*
		[0.037]		[0.033]			[0.039]		[0.036]	
BMI-for-age z-scores	1374	-0.676	1551	-0.657	-0.019	1012	-0.869	1148	-0.803	-0.066
		[0.025]		[0.023]			[0.034]		[0.031]	

Notes: The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Enrolment is a dichotomous variable indicating whether the child is enrolled school, respectively; attendance is an indicator counting the number of days the child attended by the child in the past school week (conditional on enrolment). The indicator ranges from 0 to 5 days. Grade provides the educational grade (in years) the child is currently enrolled in. SPM stands for standardized progressive matrices.

Online Appendix 9.

Treatment effects of school feeding on child probability of no having breakfast before school, number of meals consumed and dietary diversity

	No breakfast		**Number of meals**		**Dietary diversity**	
	Panel A. All children					
School feeding	-0.003		0.066		-0.027	
	(0.019)		(0.081)		(0.147)	
Observations	3,139		2,529		2,471	
R-squared	0.110		0.070		0.010	
	Panel B. Gender					
	Girls	Boys	Girls	Boys	Girls	Boys
School feeding	0.005	-0.006	0.129	0.017	-0.124	0.066
	(0.025)	(0.026)	(0.086)	(0.093)	(0.198)	(0.205)
Observations	1,184	1,361	1,173	1,356	1,143	1,328
R-squared	0.199	0.141	0.074	0.079	0.020	0.013
	Panel C. Household poverty at baseline					
	Poor	Nonpoor	Poor	Nonpoor	Poor	Nonpoor
School feeding	0.036	-0.016	0.074	0.072	-0.342	0.040
	(0.035)	(0.023)	(0.101)	(0.092)	(0.263)	(0.159)
Observations	712	2,426	591	1,938	576	1,895
R-squared	0.170	0.109	0.109	0.065	0.016	0.011
	Panel D. Geographical area					
	North	South	North	South	North	South
School feeding	0.010	-0.016	0.068	0.063	-0.045	-0.008
	(0.020)	(0.031)	(0.123)	(0.108)	(0.232)	(0.187)
Observations	1,449	1,690	1,203	1,326	1,176	1,295
R-squared	0.009	0.060	0.101	0.047	0.010	0.010

Notes: The table above illustrates intent-to-treat effects on each outcome estimated for the full sample and for the subgroups through a basic OLS regression of each outcome over school feeding arm and controlling for region dummies. We note that number of meals and dietary diversity were only collected at endline, therefore we could control for the baseline value of the outcome as in the case of no breakfast. No breakfast is an indicator variable of whether the child has had breakfast before going to school in the previous day. Number of meals is the total number of meals, including snacks, consumed by the child in the previous day. Dietary diversity is the sum of the following nine food groups consumed by the child in the previous day: cereals, roots and tubers; vitamin-A rich fruits and vegetables; other fruits and vegetables; meat and fish; eggs; legumes; dairy; oil.

Online Appendix 10.

Heterogeneity of impact by treatment modality

The analysis plan did not include the comparison in treatment effects by school feeding implementation modality. This is because, by design, the comparison between the standard GSFP and the HGSF modality was geared only toward assessing the impact of HGSF on small-holder farmers income and production (see Gelli et al. 2016, for further discussion). However, different implementation modalities may affect program impact on child learning through variation in frequency of delivery of the meal, nutrition content, type of meal, timing of delivery (e.g., breakfast *viz* lunch), etc. The HGSF, through its emphasis on improving the quality of the meal, may, theoretically, lead to better cognition and learning as compared to standard GSFP through enhanced child health (Belot and James 2011).

Table 10.1 provides ITT estimates of child learning outcomes by considering GSFP, HGSF, and control as three separate arms. For both ANCOVA and difference-in-differences estimates, the last row in each respective panel includes an F-test that assesses the equality of the treatment effect coefficients related to GSFP and HGSF. In the case of ANCOVA, assignment to the HGSF arm led to significant increases in literacy, SPM, and the three composite indicators, as compared to control. However, in either set of estimates, we were never able to reject the null hypothesis of equality of the treatment effect coefficients between HGSF and GSFP, thus suggesting lack of heterogeneity in impact by program modality. This may be either attributable to insufficient power to detect significant differences (as by design this comparison was not initially pursued) and/or to challenges in the implementation. We tend to lean toward the second explanation, also in light of similar coefficient sizes for both modalities in most cases. We hypothesize that delayed reinmbursements to caterers for the costs incurred in supplying the meals may have diluted differences between the menus of the two arms (e.g., monitoring visits highlighted substantial deviations from the guidelines related to food fortification, which was initially supposed to happen in HGSF). Thus, the nutritional differences of the meals between the two modalities may have been too limited to have heterogenous impacts on children's academic achievements through the health and cognitive channels. A similar lack of heterogeneity by modality was evident in the group-disaggregated estimates (available upon request).

Table 10.1.

Treatment effects of school feeding on child learning, by school feeding modality

	Math	**Literacy**	**Composite: math and literacy**
GSFP	0.159*	0.121	0.166*
	(0.085)	(0.084)	(0.094)
HGSF	0.136	0.143	0.169*
	(0.087)	(0.089)	(0.100)
Constant	-0.229**	-0.291*	-0.339**
	(0.104)	(0.154)	(0.151)
Observations	2,278	2,274	2,314
R-squared	0.068	0.130	0.139
P(GSFP=HGSF)	0.782	0.823	0.983

Notes: *** p<0.01, ** p<0.05, * p<0.1. The table above illustrates intent-to-treat effects on each outcome for the two school feeding modalities. GSFP is a dichotomous variable related to randomized assignment to the standard Ghana school feeding program, HGSF is a dichotomous related to assignment to "home-grown" school feeding pilot, endline is a dummy variable indicating the 2016 survey. Both models were estimated through OLS and standard errors were clustered at the community level. For each outcome, the model controls for the baseline value of the outcome, a dichotomous variable related to the randomized assignment to school feeding, and region dummies. The last row presents the p-values of a F-test assessing the equality of coefficients between the intent-to-treat effect related to GSFP and HGSF.