

RESEARCH ARTICLE

Can School Feeding Programs Reduce Malnutrition in Rural China?

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ABSTRACT

BACKGROUND: Childhood malnutrition is commonplace among poor rural communities in China. In 2012, China launched its first nationwide school-feeding program (SFP) to address this problem. This study examines the prevalence of malnutrition before and after the SFP and identifies possible reasons for the trends observed.

METHODS: Ordinary least squares regression and propensity score matching were used to analyze data from 2 cross-sectional surveys of 100 rural primary schools in northwestern China. Participants were fourth-and fifth-grade students. Outcome measures include anemia rates, hemoglobin levels, body mass index, and height for age Z scores.

RESULTS: Three years after implementation of the SFP, malnutrition rates among sample students had not fallen. The SFP had no statistically significant effect on either anemia rates or BMI, but was linked to an increase in the proportion of students with below normal height for age Z scores. Meals provided to students fell far short of national recommendations that the SPF should provide 40% of the recommended daily allowance of micronutrients.

CONCLUSIONS: Despite significant budgetary outlays between 2012 and 2015, China's SFP has not reduced the prevalence of malnutrition among sample students. To make the SFP more effective, funding and human resources both need to be increased.

Keywords: school food services; school health policy; school program evaluation; child growth and development.

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Malnutrition during early childhood can adversely affect children's short- and long-term physical and cognitive development.¹⁻³ Anemia is the most common form of malnutrition in developing countries, affecting over 30% of the world's population.⁴⁻⁷

School feeding programs (SFPs) are a common approach to combating child anemia and other malnutrition problems in developing and developed countries alike. While a number of studies have linked SFPs to both positive effects on children's growth and anthropometric indices⁸⁻¹¹ and reduced anemia rates,¹²⁻¹⁴ other research efforts have found SFPs to have no significant effect on student health.¹⁵⁻¹⁷ Problems linked to ineffective SFPs include meals that lack essential nutrients, lack of sufficient funding or

human resources, and inadequate nutritional expertise on the part of implementers.¹⁸⁻²¹

Despite rapid economic growth, malnutrition among school-aged children in rural China was high even when the nation was clearly into its middle-income stage of development. As recently as the early 2010s, reports have concluded that as many as 10 million poor rural students were anemic^{22,23} and that 20% of rural children were stunted by international standards.^{24,25} High rates of malnutrition stemmed largely from micronutrient deficiencies brought about by inadequate diets. This was particularly true in poor rural areas, where students often ate predominantly starch-based diets with little meat, vegetables, or fruit.²⁶⁻²⁸

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To combat persistent rates of malnutrition, China announced an ambitious nationwide school feeding program (SFP) in 2012.²⁹ Funded in part by the central government, the program covers an estimated 36 million children at an annual cost of 31.8 billion RMB (4.5 billion USD) for a 10-year period. The program aims to provide rural students with 40% of their recommended daily allowance (RDA) of micronutrients.²⁹ To meet this goal, a subsidy of 4 RMB (.61 USD) per student per day is allocated by the central government. Local governments are required to provide matching funds, but such allocations are rare as local governments almost always report discretionary funding shortages.²⁹ SFP funds are dispensed directly to rural school districts, and local administrators are charged with purchasing food, preparing and serving meals, and otherwise carrying out the program locally.

Positive media coverage of the program is commonplace, but little empirical evidence exists to determine if the program's objectives are being met. To our knowledge, no third-party impact evaluations have ever been published. Given widespread micronutrient deficiencies among rural children in China during the preprogram period and the scale of the program, a rigorous evaluation is warranted to determine whether the program is reaching its objective to reduce malnutrition.

Our research question is: "Is China's school feeding program effectively reducing malnutrition among rural students?" To answer this question, we first report the prevalence of malnutrition before and after the implementation of the SFP by looking at the rate of anemia among students, BMI scales, and height for age z scores (HAZ scores) in the same sample schools prior to and 3 years following the launch of the SFP. Second, we identify possible reasons to account for these changes by measuring variations in the content of meals consumed by students at home and at school before and after the SFP.

METHODS

This study was carried out in 10 prefectures within 4 provinces in northwestern China (Qinghai, Gansu, Shaanxi, and Ningxia Hui Autonomous Region). We conducted 2 cross-sectional surveys: one from 2010-2012 before the SFP was implemented, and one in 2015 when the SFP had been in place for 3 years. During the pre-SFP period from 2010 to 2012, we surveyed fourth-and fifth-grade students who had never received meals through the SFP. In 2015, we returned to the same schools and surveyed a follow-up sample of students in grades 4 and 5. This later cohort of fourth-and fifth-grade students had been receiving SFP meals for 3 years (2012-2013, 2013-2014, and 2014-2015 academic year).

Participants

To draw our study sample, we began with all 37 counties in our 10 sample prefectures that are officially designated by the Chinese government as "national poverty counties." We canvassed each county to construct a list of all rural primary schools and to determine the number of students enrolled in each school. To ensure that there were enough students in our 2 sample grades for surveying, we restricted our sampling frame to primary schools with 200-400 students total. From this list, we randomly selected 100 schools to include in our sample. To draw the most diverse and representative sample possible, we chose to only select one school from each township.

We randomly sampled 25 fourth-and fifth-grade students from each school. We chose to survey fourth- and fifth-graders (who are typically 10 to 12 years old in China) because we believe that students of this age are old enough to independently respond to survey questions. When conducting surveys with older students, biological differences between male and female students can affect results; thus we chose to survey students that are typically still prepubescent (due to the exogenous effect menarche may have on hemoglobin concentration). In total, our data include 15,748 students, divided between our baseline sample of 8411 students surveyed before SFP implementation, and our follow-up sample of 7337 students surveyed after implementation.

Instruments

The hemoglobin concentration of each student was measured by taking a finger-prick blood sample using a HemoCue Hb 201+ system (Hemocue Inc, Ängelholm, Sweden). A prick was made on the tip of the middle finger after the site was cleaned with disinfectant. The first drop of blood was cleaned off and the second drop (.05 mL) was collected to fill the microcuvette. The HemoCue Hb 201+ system was selected for the study because it is fast, convenient, and suitable for use in outpatient units while retaining accuracy and precision.³⁰

Procedure

Our data comes from 3 sources: questionnaires conducted with students, families, and schools to collect data on sample characteristics; questionnaires in which students recorded their in-home and in-school food consumption; and data on student health outcomes (namely, hemoglobin levels and anthropomorphic measures).

Enumerators collected data on student, family, and school characteristics in both our baseline and follow-up surveys. Three separate questionnaires were administered to students, caregivers, and school principals. Information collected about students included

student age, grade, sex, and school boarding status. Information collected about family characteristics included parental education levels, parental migration status, and a measure of household socioeconomic status determined by proxy measure based on ownership of 13 household assets. This proxy measure was derived using principal component analysis (PCA). Finally, we collected information from schools about student enrollment, staffing, facilities, and meal provision.

Students were also surveyed about their food consumption over the previous week. The survey was designed based on questionnaires used in previous studies^{31,32} and collected information on consumption of common food items from major food groups before and after implementation of the SFP. For example, we asked students how frequently they ate meat, dairy products, eggs, fruits, vegetables, plant-based proteins, and grains. By comparing responses from the baseline and follow-up groups, we identified changes in food consumption patterns before and after SFP implementation. Data about SFP meals were compared to the nutritional standards mandated by China's national SFP guidelines.³³

To collect data on the health outcomes of our sample students, trained nurses from the School of Medicine at Xi'an Jiaotong University carried out hemoglobin tests and took anthropomorphic measures of each student on the same day they completed the survey. The nurses also measured the weight and height of each student to a precision of 0.1 cm and 0.1 kg, following the procedural guidelines recommended by the WHO.³⁴ Students were asked to take off their coat and shoes for precise weight and height measurement.

In accordance with WHO recommendations, the outcomes used to measure health status include anemia status, body mass index (BMI), and height for age Z score (HAZ).³⁵ In calculating the anemia rates, we weighted by population of the province since the populations of our sample provinces vary dramatically. The weight for each province i is calculated as the size of the population of province i divided by the sum of the populations for all 4 provinces. The provincial weights vary from .49 for Shaanxi to .34 for Gansu to .08 for Ningxia to .08 for Qinghai. Hemoglobin concentrations were corrected for altitude following WHO recommendations. Our sample students were typically between 10 and 12 years old. Since the WHO recommends a cutoff of 115 g/L for children aged 5 to 11 and 120 g/L for children between the ages of 12 and 14, we did not use a uniform cut-off across our sample. Rather, we used the cutoff the WHO recommended based on the age of each student.

Data about height and weight were used to construct HAZ scores and BMI using WHO AnthroPlus, a software application of the WHO Reference 2007 that is used to monitor the growth of children aged

5 to 19 years. We followed internationally recognized cutoffs to calculate the percentage of children whose HAZ and BMI were below the international mean.³⁵ Individual age was reported in months. The BMI measure was calculated as body weight (kg) divided by height in meters.

Data Analysis

All analysis was performed using Stata 14.0 (StataCorp, College Station, TX), calculating robust standard errors to adjust for clustering by school. Descriptive statistics (means and standard deviations) were used to summarize sample characteristics, student food consumption, and student health status before and after the SFP implementation. The prevalence rates of anemia, BMI below normal weight, and HAZ scores below the international average served as the main student health status indicators. A χ^2 -test was used to compare differences in prevalence rates.

Multivariate OLS with school fixed effects and propensity score matching regressions were used to estimate the impact of the SFP. The 2 cohorts of school children we surveyed before and after the SFP were from the exact same schools, allowing us to use school fixed effects to control for school-level characteristics. A conceptual model of risk factors for anemia among school-aged children was adapted from previous studies and used to select the covariates in the regression model.^{20,36} We considered the following variables as potential confounders in the multivariate analysis: age, sex, school boarding status, parental education levels, parental migration status, and household socioeconomic status. Our primary analysis used PSM, a frequently used matching technique.³⁷ Matching techniques work by comparing characteristics of students in the control group to those in the test group and then matching each student in the control group with a similar student from the test group for analysis. Since participants in the 2 groups may differ systematically, this helps to correct for selection bias in the different arms of the sample.

The matching strategy we used was propensity score matching (PSM). The propensity score as defined by Rosenbaum and Rubin is the conditional probability of a participant receiving treatment based on observed covariates.^{38,39} PSM is a correction strategy that attempts to correct for selection bias, providing an alternative for estimating treatment effects when systematic differences between control group and test group mean treatment assignment is not random.^{38,40} In this case, the SFP is considered the treatment. We used the same covariates as in OLS to create propensity scores for each participant. Moreover, we matched students within the same schools as strata (since the schools are the same pre- and post-SFP). Participants from pre-SFP and post-SFP groups were

Table 1. Characteristics before Matching (Overall Sample)

Characteristics	Before SFP	After SFP	p value	Standardized Difference, %
Students characteristics				
Mean age (years)	11.50 (1.50)	11.48 (1.21)	.202	-2.1
Male sex, N (%)	4337 (.51)	3714 (.50)	.235	-1.9
Boarding at school, N (%)	1544 (.18)	1894 (.26)	<.001	18.2
Mother with ≥9 years of education (%)	0.23 (.42)	0.26 (.44)	<.001	6.3
Father with ≥9 years of education (%)	0.44 (.49)	0.44 (.50)	.692	-0.6
Mother out-migrated for work, N (%)	0.22 (.39)	0.29 (.45)	<.001	16.2
Father out-migrated for work, N (%)	0.54 (.47)	0.54 (.50)	.513	1.0
Family asset	0.00 (.83)	0.00 (.85)	.999	-0.0
Health status				
Anemia rate	0.16 (.37)	0.16 (.37)	.982	
Hemoglobin level (g/L)	130.47 (11.97)	129.34 (11.38)	<.001	
Body mass index	16.48 (1.79)	16.57 (2.19)	.107	
BMI Z score	-0.53 (.97)	-0.57 (1.07)	.199	
BMI below-average weight	0.21 (.41)	0.25 (.43)	.001	
Height for age Z score	-0.73 (1.52)	-0.92 (1.07)	<.001	
Below-average height for age z score	0.73 (.44)	0.82 (.39)	<.001	
Sample size	N = 8411	N = 7337		
Survey time	2010-2012	2015		

matched using a nearest neighbor's algorithm without replacement. Standardized differences were estimated for all the covariates before and after matching to assess pre-match imbalance and post-match balance.

RESULTS

Sample Characteristics

The characteristics of sample students and families before and after implementation of the SFP are reported in Table 1. Across all 100 sample schools the average age of students in the pre-SFP sample was 11.50 years, and the average age in the post-SFP sample was 11.48 years ($p = .202$). Male students comprised 51% of our pre-SFP sample and 50% of our post-SFP sample ($p = .235$). There were no significant differences between the 2 samples in terms of the age and sex of students. The percentage of students in the post-SFP sample who boarded at school (26%) was higher than in the pre-SFP sample (18%), and this difference is significant ($p < .001$).

Family education levels and working habits differed slightly between the 2 cohorts. In the pre-SFP sample 23% of mothers had completed 9 or more years of schooling, while in the post-SFP sample this proportion was 26%. Although the difference was small (3 percentage points), it was significant ($p < .001$). For the fathers of sample students, 44% had completed 9 or more years of schooling both pre- and post-SFP implementation ($p = .692$). The percentage of mothers who migrated for work also differed between the 2 study periods ($p < .001$). In the pre-SFP sample, 22% of the mothers worked as migrant workers while in the follow-up sample 29% were migrant workers

($p < .001$). The percentage of fathers that were migrant workers was constant across both samples (54%, $p = .513$).

Principal component analysis (PCA) was used to derive a household socioeconomic index from information on ownership of certain household assets. After standardization, the mean of the index before and after SFP implementation were both zero, indicating that there was no significant change in the socioeconomic status of sample households between the pre-SFP and follow-up survey samples ($p = .999$).

Student Health Status

Student health status indicators are reported in Table 1. The table provides the *t* tests results measures of the anemia rates, mean Hb concentrations, and the prevalence of BMI and HAZ scores below international averages before and after SFP implementation.

According to the raw (unweighted) data, 16% of students in the sample were anemic before the implementation of the SFP in 2010-2012. After 3 years of implementation, the anemia prevalence did not fall; the raw (unweighted) prevalence rate was still 16% in 2015 ($p = .982$). When weighting the sample by population, the anemia rate actually rose from 19% to 25% from before the SFP to after the SFP. The mean Hb concentrations was 130 g/L before SFP implementation, it decreased to 129 g/L after SFP ($p < .001$).

In terms of our anthropomorphic measures, there was no statistically significant improvement. BMI of our sample students before SFP implementation was 16.48. After the implementation, the average BMI did not improve; it was 16.57 after implementation but the

Table 2. Characteristics Balance Check after Matching

	Before SFP	After SFP	p value	Standardized Difference, %
Students characteristics				
Mean age (years)	11.49 (1.49)	11.40 (1.20)	.442	1.6
Male sex, M (%)	2518 (.51)	2267 (.51)	.563	-1.2
Boarding at school, N (%)	823 (.17)	1007 (.22)	.827	0.5
Mother with ≥9 years of education (%)	0.25 (.43)	0.28 (.45)	.620	-1.1
Father with ≥9 years of education (%)	0.45 (.50)	0.46 (.50)	.072	-3.8
Mother out-migrated for work, N (%)	0.24 (.41)	0.30 (.46)	.613	1.1
Father out-migrated for work, N (%)	0.54 (.49)	0.55 (.50)	.104	5.2
Family asset	0.02 (.83)	-0.06 (.85)	.442	-1.6
Sample size	N = 4936	N = 4466		
Survey time	2010-2012	2015		

Table 3. Estimated Impact of School Feeding Program on Student Health Status

Outcome	OLS with School Fixed Effects				Propensity Score Matching			
	Before SFP	After SFP	Difference Between Means (95% CI)	p Value	Before SFP	After SFP	Difference Between Means (95% CI)	p Value
Anemia rate	.162	.162	-.008 (-0.041-0.024)	.611	.180	.162	-.018 (-0.036, 0.001)	.058
Hemoglobin (g/L)	130.47	129.34	-.657 (-2.003-0.690)	.335	130.09	129.34	-.749 (-1.375, -0.123)	.019
BMI below normal weight	.212	.250	.011 (-0.030-0.052)	.603	.241	.248	.007 (-0.041, 0.056)	.758
Height for age Z score below average	.727	.818	.063 (0.026-0.099)	<.001	.789	.823	.034 (-0.017, 0.085)	.194

difference was not statistically significant ($p = .107$). The average BMI Z score also did not improve, and in fact, the point estimate deteriorated. The average Z score was $-.53$ before the SFP; the score was $-.57$ after the SFP (the difference is not statistically significant, $p = .199$). The prevalence of BMI below normal weight rose; the measured prevalence was 21% before and 25% after SFP implementation ($p = .001$). The difference in average height for age Z score before and after SFP implementation was also statistically significant. The average HAZ score before SFP was $-.73$ and it deteriorated to $-.92$ in the 2015 cohort. This difference was significant ($p < .001$). We also found that more students had HAZ scores below the international average after SFP implementation (82%) than before (73%), and this difference was significant ($p < .001$).

Balance Check after Propensity Score Matching

Table 2 reports the balance check on student and family characteristics after propensity score matching. To assess differences between the pre-SFP and post-SFP groups, we calculated the standardized differences and p value for the mean difference. Standardized differences is the mean difference divided by the pooled standard deviation, expressed as a percentage.⁴¹ A standard difference that is less than 10% indicate a negligible difference in the mean or prevalence of a covariate between groups.^{39,41} Table 2 shows that after matching, characteristics were balanced between

the 2 groups (the standardized difference for each characteristic was <10).

Estimation of the SFP's Impact on Student Malnutrition

Table 3 reports the results of the multivariate OLS with school fixed effects and propensity score matching regressions. The results of the multivariate OLS regression show that there was no significant relationship between the SFP and students' anemia rates, hemoglobin levels, or prevalence of below-average BMI. We found that after the SFP, the prevalence of students who had below-average HAZ scores was 6 percentage points higher than before, a difference significant at the 1% level ($p < .001$).

The results of the PSM analysis are quantitatively similar to the OLS results (Table 3). Analysis using the nearest neighbor matching method shows that the SFP had no significant effect on the anemia rate of students, prevalence of below-average BMI or prevalence of below-average HAZ scores. In contrast, the matched analysis shows the SFP had a negative .749 g/L effect on the hemoglobin level of students ($p = .019$).

Nutrition Provision at Home and School

Table 4 presents the weekly food consumption frequency of students before (which is only in-home consumption, since there was almost no in-school consumption) and after SFP implementation (which is SFP-provided consumption). Compared to the consumption of food at home before the

Table 4. Student Food Consumption Frequency Before and After School Feeding Program

Food Frequency Questionnaire				
	Before SFP	After SFP		
	Food Consumption Frequency at Home	Food Consumption Frequency at School	Difference	p Value
	(1)	(2)	(2)–(1)	
Meat	2.63 (4.00)	3.74 (4.36)	1.113**	.010
Milk	1.12 (1.64)	2.09 (2.24)	.977**	<.001
Egg	.98 (1.37)	2.81 (2.27)	1.827**	<.001
Vegetables	3.70 (3.51)	2.72 (3.60)	−.974**	.005
Beans/Nuts	1.81 (2.42)	1.38 (2.52)	−.426	.054
Grains	3.61 (3.21)	3.17 (3.70)	−.439	.305
Fruits	2.90 (4.02)	1.59 (3.48)	−1.310**	<.001

SFP, student food consumption changed in several ways following program implementation. Students on average consumed meat 1.11 more times per week (2.63 versus 3.74 times per week, $p < .01$), milk .98 more times per week (1.12 versus 2.09 times per week, $p < .01$), and eggs 1.83 more times per week (2.81 versus .98 times per week, $p < .001$) following SFP implementation. In contrast, we found that students ate vegetables, beans/nuts, grains, and fruits less frequently after SFP implementation. The frequency of vegetable consumption dropped from 3.70 times per week to 2.72 (a decrease of .97 times per week, $p < .01$). Frequency of fruit consumption also decreased from 2.90 times per week to 1.59 (a decrease of 1.21 times per week, $p < .001$). Slight decreases in

the frequency of consumption of beans/nuts and grains were present but not significant ($p = .054$; $p = .305$).

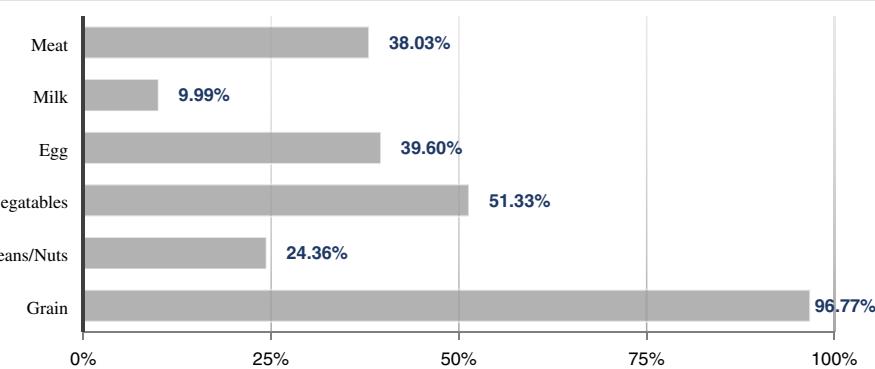
Figure 1 depicts how in-school daily food consumption by sample students compares to the national SFP guidelines. Our data show that the SFP fulfills only a fraction of the national requirement that SFP meals provide students with at least 40% of their recommended daily nutritional intake. This shortfall was especially apparent in the consumption of meat, milk, eggs, and beans/nuts, as the average amounts consumed by sample students were all less than half of what is suggested in the national standards. Vegetable consumption was also particularly low, as students on average consumed slightly more than half (51.3%) of the SFP standard. Among the food categories for which we had data, only the consumption of grains neared national guidelines, reaching 96% of the national standard.

DISCUSSION

This study provides the first rigorous evaluation of one of the world's most expansive school feeding programs. We believe this research contributes to the literature surrounding school feeding programs as it draws on 2 periods of cross-sectional data collected from the exact same schools with large sample sizes. Without independently collected data, it may not have been possible to examine the state of the school feeding program, as it is often difficult to access administrative data in China. The current study also draws on data from in-home and in-school sources that shed further light on previously unexplored aspects of nutritional challenges of rural children in China.

Our data shows that after the implementation of China's national SFP, a significant share of students in rural China still suffer from poor health outcomes arising from malnutrition. The prevalence of anemia among students in our sample did not fall, and using the raw (unweighted) measures of prevalence was

Figure 1. SFP Actual Daily Food Provision Compared to National Standards. Note: There is no fruit intake recommendation in the national guidelines



16% both before and after the implementation of the SFP. When weighting the anemia prevalence measures by provincial population, the share of children with anemia actually rose from 19% before the SFP to 25% in 2015 after the SFP. We also found that anthropometric measures (BMI scales and HAZ scores) did not show any improvement and in some cases showed deterioration.

Although we found that mother's education and migration status was significantly higher among the post-SFP cohorts, we do not believe these compositional changes will bias our results. First, the increase in the share of mothers with more than 9 years of education is small—only 3 percentage points. Research indicates that when the mother is more educated, she may have better knowledge about health care and nutrition, and thus behave in a way that leads to a healthier child.⁴²⁻⁴⁴ Therefore, one would expect the post-SFP students, whose mothers are slightly more educated, to have better rates of nutrition, but they do not, further strengthening the conclusion that the SFP did not work as intended. The percentage of mothers that have migrated out of the area for work increased from 23% before the SFP to 29% after ($p < .001$). One possible cohort effect is that better off families may migrate more readily, take their children with them, and leave behind only the less well-off and presumably less healthy student population, thus presenting a downward bias to the estimate of the effect of the SFP. However, research suggests that as little as 4% of migrating mothers bring their children with them to urban areas.⁴⁵ In fact, it may also be reasonable to conclude that more mothers may migrate without their children after the beginning of the SFP precisely because the SFP frees them up to leave the home rather than stay to prepare food during the day for their children. For these reasons, we do not believe the statistically significant difference in mother's education level or the rise in migrated mothers unduly biases our conclusions on the effectiveness of the SFP.

Our finding that China's SFP did not raise student nutritional status is somewhat surprising considering that China's SFP meets many of the conditions that have been linked to success in other SFPs. A Cochrane Review on SFPs sets forth various factors linked to program success, including clear nutritional deficiency in the target group, well-organized schools, localized implementation of SFP, and close supervision of food consumption.^{15,18} According to our analysis, none of these factors are missing in China. Nutritional deficiencies are commonplace, SFP implementation is decentralized by school district, and there exists a well-organized school system that routinely supervises meal consumption and boasts virtually zero rates of staff absenteeism. In this sense, the findings of the current study are surprising, and warrant

consideration of additional driving factors of SFP outcomes.

However, our finding is consistent with and confirms the results of other studies which show that SFP nutritional outcomes are highly dependent on the quality of food provided.^{9,16,18,20} Multiple SFPs conducted over decades have been shown to be ineffective in raising student nutrition. SFPs that provide food with insufficient levels of micronutrients are shown to be less effective at raising student health and academic outcomes.¹⁸ The current study's finding that China's SFP routinely meets less than half of the nutrition recommendations, along with the mixed outcomes indicated by our results, confirms the important role that nutrient rich foods play in the outcomes of SFPs.

Ultimately we believe the program's main problem is a lack of sufficient financial and human capital resources. More than 80% of school principals surveyed reported that the 4 RMB per student per day provided by the national government is not sufficient to supply a nutritious meal. Interviews also revealed that local officials and administrators lacked the experience and knowledge necessary to run the SFP. We also found several administrative decrees that placed overwhelming emphasis on administrative and food safety concerns but failed to stress the importance of providing nutritious food to students.

Limitations

Further research remains necessary on this topic. Our study sample is not nationally representative, as it was drawn from 4 provinces in northwestern China. Although our study found that the allocation of 4 RMB provided for each student per school day from the national government is not sufficient to supply a nutritious meal, more thorough research and cost analysis is needed to determine what amount would be sufficient. Further research should also explore the effects of school feeding programs on other outcomes related to growth and development, such as morbidity, muscle mass, attention and behavior, academic achievement, and cognitive function.

Conclusion

The absence of improvement in health outcomes following implementation of China's SFP suggests that the program is not meeting its goal of providing sufficiently micronutrient-rich meals that improve student nutrition and health. A significant share of students in rural China still suffer from malnutrition. The SFP's main problems are insufficient subsidies and shortcomings in local nutrition expertise.

IMPLICATIONS FOR SCHOOL HEALTH

The findings of this study confirm that health improvements under SFPs are highly dependent on the nutritional quality of meals provided. If SFPs are to succeed in bringing about positive health outcomes, program planning must include detailed nutritional standards and make sure the path to meet these standards is clear to those implementing the program. To improve China's SFP, we recommend that more resources per meal be allocated to the program and more nutrition support provided for local schools and educators.

A further method that could help improve SFP student health outcomes is the provision of multivitamins at school. Luo et al found that, in the absence of any other intervention, rural schools experienced decreased anemia rates and improved academic outcomes among students after distributing multivitamins. Given that a single iron supplement costs only .3 RMB per student per day, this appears to be a cost-effective way to improve nutritional outcomes.

Human Subjects Approval Statement

The Stanford University Institutional Review Board (IRB Protocol ID #19748) approved this study. The caregivers of all participants provided informed oral consent, and the students themselves provided oral assent prior to the start of study activities. Students who were found to have severe anemia were referred to the local hospital for treatment.

Conflict of Interest

The authors have no conflicts of interest to declare.

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