Nutrition and education: a randomized trial of the effects of breakfast in rural primary school children[1–3]

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ABSTRACT Hunger during school may prevent children in developing countries from benefiting from education. Although many countries have implemented school feeding programs, few programs have been rigorously evaluated. We conducted a randomized, controlled trial of giving breakfast to undernourished and adequately nourished children. The undernourished group comprised 407 children in grades 2–5 in 16 rural Jamaican schools (weights-for-age ≤ -1 SD of the National Center for Health Statistics references) and the adequately nourished group comprised 407 children matched for school and class (weights-for-age > -1 SD). Both groups were stratified by class and school, then randomly assigned to breakfast or control groups. After the initial measurements, breakfast was provided every school day for 1 school year. Children in the control group were given one-quarter of an orange and the same amount of attention as children in the breakfast group. All children had their heights and weights measured and were given the Wide Range Achievement Test before and after the intervention. School attendance was taken from the schools' registers. Compared with the control group, height, weight, and attendance improved significantly in the breakfast group. Both groups made poor progress in Wide Range Achievement Test scores. Younger children in the breakfast group improved in arithmetic. There was no effect of nutritional group on the response to breakfast. In conclusion, the provision of a school breakfast produced small benefits in children's nutritional status, school attendance, and achievement. Greater improvements may occur in more undernourished populations; however, the massive problem of poor achievement levels requires integrated programs including health and educational inputs as well as school meals. *Am J Clin Nutr* 1998;68:873–9.

KEY WORDS School feeding, children, undernutrition, educational attainment, Jamaica, school breakfast

INTRODUCTION

In the past decade, increasing numbers of children in developing countries have been enrolled in school; their achievement levels, however, have often been disappointing (1). It has been suggested that poor health and nutrition may hinder these children's ability to learn (2) and hunger in school is one of the conditions that has been implicated. Several laboratory studies showed that missing breakfast detrimentally affects children's cognition (3, 4) and that undernourished children are more likely to be affected (5, 6). Similarly, a short-term study of providing breakfast in school found that undernourished children were more likely to benefit from such a program (7). However, a recent study showed that providing breakfast benefited children's classroom behavior only if they were in well-equipped and well-organized schools, and that the behavior of children in poorly organized and overcrowded schools actually deteriorated (8). It is therefore not possible to conclude from these data whether school feeding programs would benefit children's achievement levels.

Many countries, both developing and developed, have invested large sums of money in school feeding programs to improve attendance, achievement levels, and nutritional status, and sometimes to provide extra income for poor families by reducing the amount of money they spend on food. The World Food Program alone spent US$763 million on primary and secondary school feeding programs in 1996 (unpublished data from the World Food Program, Rome, 1997). To make the best use of resources, policymakers need to know the benefits that can be expected from investment in school feeding programs; however, despite the large amount of resources invested in school meals, evaluations have generally lacked scientific rigor (9–11). Early studies often had no preintervention measures or control groups. More recent studies had improved designs but usually did not randomly assign children to meals or a control group (12, 13). In addition, studies have generally been short term, lasting no more than 3 mo (12–14). When random assignment was used, schools were the unit of assignment (14). However, the quality of schools varies substantially and large numbers are necessary to ensure that study groups are equivalent. Furthermore, the power to detect differences when data are analyzed at the school level may be limited.

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We report the results of a randomized, controlled trial of giving breakfast to Jamaican primary school children. It is the first study we know of in which the children were randomly assigned to treatment or control groups within the same class and school, thus ensuring equivalence between the groups. In addition, the breakfast was provided for 1 school year. The aims of the study were to determine *1*) the effect of providing a school breakfast on children's attendance, nutritional status, and achievement in arithmetic, spelling, and reading; *2*) whether the nutritional status or age of the children modified the effect; and *3*) whether the children spent less money in school if they were given breakfast.

SUBJECTS AND METHODS

Subjects

The project was conducted in a mountainous, rural area in Jamaica. The children in these areas were considered most likely to benefit from a school feeding program because they came from poor families and had to walk long distances to school.

All schools in the study area were visited and were selected if the school administration was willing to participate, if the school had a room available in which to serve the meals (eg, a kitchen), and if there were >350 children enrolled. A total of 16 primary schools were chosen out of a possible 21; of the remaining schools, 3 were too small and the principals of the other 2 schools did not wish to participate. All children in grades 2–5 were weighed and their dates of births were collected from school records. Four hundred seven children whose weights-for-age on screening were ≤ -1 SD of the National Center for Health Statistics (NCHS) references (15) were selected as the undernourished group. This definition of undernutrition was the lowest at which we could identify sufficient numbers of children. The undernourished group was matched by age (±3 mo), sex, school, and class with 407 children with weights-for-age > -1 SD of the NCHS references, who formed the adequately nourished group. Children who had repeated a grade were excluded.

Permission to conduct the study was obtained from the Ministry of Education and written, informed consent was obtained from the children's parents. The study was designed so that only a small proportion of children in each class were given breakfast so that the remaining children would not feel disadvantaged.

Measurements

The Wide Range Achievement Test (WRAT) (16), which comprises 3 subscales (reading, spelling, and arithmetic), was used to assess school achievement. This test has been modified and used in several studies in Jamaica, where it is highly reliable and predicts teachers' ratings of achievement levels (17–19). Raw scores are reported instead of scores that were converted to grade levels. The spelling and arithmetic tests, which were written, were conducted in small groups whereas the oral reading test was given individually.

The children's school attendance for the current school year was collected from the school registers and expressed as a percentage of total possible days. School attendance during September and October, before the intervention began, was taken as the baseline period. A questionnaire was administered individually to the children to obtain information on their socioeconomic status, the amount of money they brought to school, and the type of breakfast they had eaten at home on the day of the interview (breakfast history). The quality of their school uniforms and the number of books and writing materials they brought to school were observed. Ratings were computed for the quality of housing (crowding, water, sanitation, and electricity; range: 0–7), number of household possessions (radio, television, refrigerator, and type of stove; range: 0–5), quality of school uniforms (range: 0–4), possession of school materials such as exercise books and textbooks and writing materials (range: 0–6), and the quality of the breakfast consumed at home (type of food and drink consumed; range: 0–4).

Weights and heights were measured according to standard procedures (20) and converted to weight-for-age and height-for-age *z* scores of the NCHS references. Body mass index (BMI; in kg/m^2) was also calculated.

All tests were administered by 1 of 5 testers who were blinded to the children's group assignment. Over the duration of the study, test-retest reliabilities were 0.96, 0.96, and 0.89, respectively, for reading, spelling, and arithmetic (n = 791). Interobserver agreement between the trainer and the testers was >96% for the questionnaire (n = 106). The homes of 20 study children were observed to check the validity of the children's answers on the questionnaires. Mean percentage agreement between these observations and the children's answers ranged from 70% to 95%. Intraclass correlation coefficients between those taking anthropometry measurements and the trainer were 0.999 for weight and 0.998 for height for 20 children before the study started and for 76 children during the study.

Procedure

All subjects were tested, measured, and interviewed at the start of the 1994 academic year. They were then stratified by nutritional group and class in each school and randomly assigned to the breakfast or control group. The breakfast consisted of a cheese sandwich or spiced bun and cheese and flavored milk and supplied 2419–2953 kJ (576–703 kcal) and 27.1 g protein. The control group was given one-quarter of an orange, which served as a proxy for a placebo and supplied 76 kJ (18 kcal) and 0.4 g protein. All meals were served before the start of classes on all school days. The control and breakfast groups were served in separate rooms or at separate times under the supervision of a teacher who recorded the children's consumption. The measurements were repeated at the end of the school year.

Data analysis

The study design is given in **Figure 1**. Eight hundred fourteen children were enrolled in the study. One child in the adequately nourished control group was repeatedly absent and did not have enrollment or repeat measurements. An additional 22 children did not complete the trial, 15 moved to schools outside the study area and 7 were absent from school on repeated visits and could not be located during home visits and were therefore not included in the analyses of the effects of breakfast.

The effect on the children's growth of providing breakfast was determined by using multiple regression analyses, controlling for the children's initial measurements, age, sex, and nutritional group. The housing rating was entered stepwise in the analysis to account for possible effects of socioeconomic status. We also investigated whether the effect of breakfast was modified by the children's age, sex, nutritional status, or socioeconomic status by entering stepwise interaction terms between each of these variables and the treatment group. Separate multiple regression analyses were calculated for height, weight, and BMI.

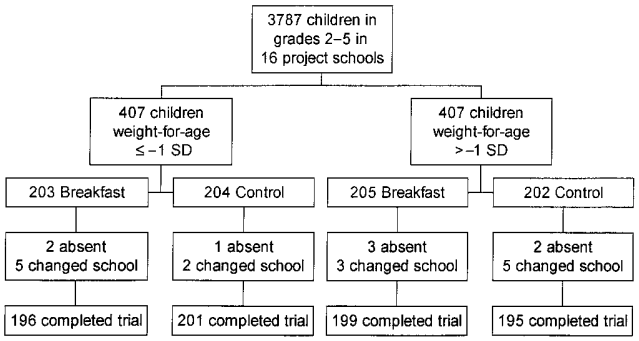

FIGURE 1. Study design of a breakfast trial in 16 rural Jamaican schools and the numbers of children remaining to the end. Children were assigned to the undernourished or adequately nourished groups according to weight-for-age (≤ −1 or > −1 SD of National Center for Health Statistics references).

Because of the hierarchical structure of the study, for the analyses of the educational variables a multilevel modeling procedure (21) was used to account for variation in achievement and attendance among classes and schools. Separate analyses were conducted with achievement in spelling, arithmetic, and reading and attendance as the dependent variables. Initial score, grade (coded as grades 2 and 3 = 0 and grades 4 and 5 = 1), sex, nutrition group (undernourished or adequately nourished), and treatment group (control or breakfast) were included as covariates for their fixed effects in all models. In addition, the housing rating and the following interaction terms were entered stepwise: grade × treatment, nutrition group × treatment, housing × treatment, and sex × treatment. Interaction terms were included in the model if they were significant at $P < 0.1$. The random parameters were the intercept variances at the pupil, class, and school levels. In a random slopes model, treatment effects did not vary among schools and so the simpler variance components model is reported. Differences between means and main effects in the multilevel analyses were considered statistically significant at $P < 0.05$ and at $P < 0.1$ for interaction terms. Analyses were conducted with SPSS for WINDOWS (release 6.0; SPSS Inc, Chicago) and the MLN package for multilevel analysis (22).

RESULTS

Sample description

The mean age of the children was 107.6 ± 14.7 mo and there were no significant differences among the groups. There were also no significant differences between the breakfast and control groups within each nutritional group for any of the measures of socioeconomic status or school materials (**Table 1**). There were differences, however, between adequately nourished and undernourished children. Adequately nourished children had a significantly higher housing rating, more household possessions, better uniform ratings, and more school materials (books and pens or pencils) when age and sex were controlled for than did undernourished children. There was no significant difference in the breakfast rating between the groups.

The school achievement test was standardized and developed in the United States and has not been standardized in Jamaica. At enrollment, when the children's scores were converted to grade levels according to the test norms, the mean scores in arithmetic ranged from grade level 1.8 for children in grade 2 to grade level 3.2 for children in grade 5. Reading and spelling scores ranged from grade level 1.3 and 1.6 for children in grade 2 to 2.3 and 2.4 for children in grade 5, respectively. There was no significant difference between the breakfast and control groups within each nutritional group in school achievement scores, attendance, or nutritional status (**Table 2**). The adequately nourished children, however, had significantly higher scores in arithmetic, reading, and spelling than did the undernourished children when age and sex were controlled for. Their school attendance was also significantly better than that of the undernourished group. These differences remained at the end of the intervention except for reading, for which the difference was no longer significant. As expected from the selection criteria, the adequately nourished children were significantly better than the undernourished group in all measures of nutritional status. The mean BMIs of the adequately nourished children were similar to the 50th percentile values for black American children, whereas those of the undernourished approached the 15th percentile (23).

Effects of breakfast

The analyses of the effects on achievement of providing a school breakfast are shown in **Table 3**. The children's initial scores predicted their scores at the end of the year. Because the initial scores are included in the analyses, the results in this table can be interpreted as the effect of each independent variable on the change in the children's scores over the school year. Girls improved more than boys in all 3 subscales and children in grades 2 and 3 improved more in arithmetic but less in spelling than children in grades 4 and 5. The children's nutritional status was not related to their change in achievement.

TABLE 1
Socioeconomic status, school materials, and breakfast rating on enrollment by treatment and nutritional group for children in 16 rural Jamaican schools[1]

	Undernourished children		Adequately nourished children	
	Control group (n = 204)	Breakfast group (n = 201)[2]	Control group (n = 200)[3]	Breakfast group (n = 205)
Housing rating (0–7)	4.2 ± 1.5	4.0 ± 1.5	4.6 ± 1.5[4]	4.7 ± 1.5[4]
Possessions (0–5)	2.5 ± 1.6	2.5 ± 1.6	3.2 ± 1.6[4]	3.0 ± 1.7[4]
Uniform rating (0–4)	2.7 ± 1.2	2.4 ± 1.3	2.7 ± 1.2[4]	2.7 ± 1.3[4]
School materials (0–6)	2.8 ± 1.5	2.8 ± 1.7	3.2 ± 1.6[4]	3.1 ± 1.6[4]
Breakfast rating (0–4)	3.3 ± 0.9	3.2 ± 0.9	3.2 ± 0.9	3.3 ± 0.8

[1] $\bar{x}$ ± SD.
[2] Two children in this group were not interviewed.
[3] One child in this group was not interviewed.
[4] Significantly different from undernourished children in the same group and in both groups combined, $P < 0.05$ (ANCOVA controlling for age and sex).

TABLE 2
School achievement, attendance, and nutritional status on enrollment and after the intervention by treatment and nutritional group for children in 16 rural Jamaican schools[1]

	Undernourished children		Adequately nourished children	
	Control group (n = 204)	Breakfast group (n = 203)	Control group (n = 201)	Breakfast group (n = 205)
School achievement[2]				
Arithmetic				
At enrollment	18.6 ± 6.6	18.0 ± 7.2	19.9 ± 6.7[3]	19.8 ± 6.4[3]
At intervention end	20.9 ± 6.7	20.6 ± 7.1	22.1 ± 6.8[3]	22.3 ± 6.4[3]
Reading				
At enrollment	24.2 ± 13.6	23.0 ± 13.9	25.6 ± 14.1[3]	25.2 ± 13.3[3]
At intervention end	28.0 ± 14.7	26.8 ± 15.8	29.4 ± 14.8	28.8 ± 15.2
Spelling				
At enrollment	14.8 ± 8.9	14.5 ± 8.9	15.8 ± 8.9[3]	15.7 ± 8.5[3]
At intervention end	17.3 ± 10.2	16.8 ± 10.6	18.2 ± 10.1[3]	18.3 ± 10.1[3]
Attendance (% of possible days)				
At enrollment	81.2 ± 14.8	81.8 ± 14.9	84.5 ± 14.6[3]	84.2 ± 13.7[3]
At intervention end	67.9 ± 17.7	71.0 ± 16.0	71.7 ± 18.7[3]	73.6 ± 15.8[3]
Nutritional status				
Height (cm)				
At enrollment	124.5 ± 7.0	123.6 ± 7.2	134.2 ± 8.4[3]	134.5 ± 7.9[3]
At intervention end	127.8 ± 7.0	127.0 ± 7.4	137.8 ± 8.7[3]	138.0 ± 8.1[3]
Weight (kg)				
At enrollment	22.4 ± 3.0	21.8 ± 3.0	29.6 ± 5.4[3]	29.4 ± 4.8[3]
At intervention end	24.0 ± 3.3	23.6 ± 3.3	31.8 ± 6.1[3]	31.8 ± 5.3[3]
Weight-for-age (z score)				
At enrollment	−1.49 ± 0.32	−1.65 ± 0.36	0.13 ± 0.61[3]	0.12 ± 0.52[3]
At intervention end	−1.46 ± 0.33	−1.53 ± 0.35	0.11 ± 0.63[3]	0.17 ± 0.53[3]
Height-for-age (z score)				
At enrollment	−1.27 ± 0.65	−1.44 ± 0.70	0.33 ± 0.79[3]	0.43 ± 0.79[3]
At intervention end	−1.26 ± 0.64	−1.38 ± 0.69	0.34 ± 0.82[3]	0.45 ± 0.79[3]
Body mass index (kg/m^2)				
At enrollment	14.38 ± 0.92	14.23 ± 0.98	16.35 ± 1.50[3]	16.14 ± 1.40[3]
At intervention end	14.61 ± 0.96	14.56 ± 1.00	16.63 ± 1.64[3]	16.60 ± 1.54[3]

[1] $\bar{x}$ ± SD.
[2] Results on the Wide Range Achievement Test (16). Raw scores are reported.
[3] Significantly different from undernourished children in the same group and in both groups combined, $P < 0.05$ (ANCOVA controlling for age and sex).

There was a significant benefit of breakfast to children's achievement in arithmetic; the interaction between grade and treatment indicated that this benefit was seen mainly in the younger children (grades 2 and 3). There were no significant effects of treatment on spelling or reading. The interaction between grade and treatment in spelling was the result of a tendency for the scores of children in grades 4 and 5 to increase with breakfast, whereas those of children in grades 2 and 3 tended to decrease; however, neither change was significant. Most of the variance in achievement was at the pupil level; however, 4–11% was accounted for by variance among the classes.

Children who received breakfast had significantly better attendance (Table 3). As expected, children whose attendance was better before the intervention continued to have better attendance for the rest of the school year, although overall attendance decreased as the year progressed. The only other variable that predicted attendance was quality of housing: children from better homes attended school more regularly than did those from poorer homes. As with achievement, most of the variance in attendance was at the pupil level.

The results of the regression analyses for weight, height, and BMI are given in **Table 4**. The coefficients for treatment group represent the difference between the breakfast and control groups, controlling for the covariates in the model. There were significant effects of treatment group in all 3 regressions. Children in the breakfast group gained more weight and increased in height and BMI significantly more than did those in the control group. The heights and BMIs of children in the adequately nourished group increased significantly more than did those of children in the undernourished group. Girls increased more than boys in height, weight, and BMI. The housing rating was significant in the regression of height: those from poorer homes gained more height than did those from better homes. There were no significant interactions between treatment group and any of the variables given above.

The change in the amount of money brought to school was used as a proxy for income transfer to the families; there was no significant effect of treatment on this variable. Children in the breakfast group were therefore not given less money for school and the program did not result in any significant income transfer to the families. Similarly, there was no significant difference in the children's breakfast history before or during the breakfast program.

DISCUSSION

The children who received breakfast showed small but significant improvements in attendance and nutritional status compared with those in the control group. The younger children

TABLE 3
Multilevel analyses of the effects of breakfast on achievement in arithmetic, spelling, and reading and on attendance[1]

	Arithmetic	Spelling	Reading	Attendance
Fixed parameters				
Intercept	3.40 (0.55)[2]	−0.07 (0.40)	1.66 (0.58)	−4.41 (2.77)
Initial score	0.85 (0.02)[2]	1.12 (0.01)[2]	1.06 (0.01)[2]	0.79 (0.03)[2]
Sex[3]	0.81 (0.24)[2]	0.92 (0.22)[2]	0.84 (0.32)[2]	1.18 (0.83)
Grade[4]	1.06 (0.40)[2]	−1.35 (0.33)[2]	−0.60 (0.36)	0.26 (0.96)
Nutrition group[5]	0.17 (0.22)	0.01 (0.19)	−0.26 (0.29)	0.25 (0.80)
Treatment group[6]	0.71 (0.31)[2]	−0.50 (0.27)	−0.12 (0.29)	2.32 (0.78)[2]
Grade × treatment	−0.85 (0.44)[7]	0.98 (0.39)[2]	—	—
Housing rating	—	—	—	1.57 (0.29)[2]
Random parameters				
School	0.43 (0.30)	0.07 (0.12)	0.66 (0.40)	3.91 (2.75)
Class	1.17 (0.38)	0.58 (0.24)	0.70 (0.44)	7.16 (3.62)
Pupil	9.39 (0.51)	7.38 (0.40)	16.11 (0.87)	118.50 (6.43)

[1] Coefficient; SE in parentheses.
[2] $P < 0.05$.
[3] Girls = 1, boys = 0.
[4] Grades 2 and 3 = 0, 4 and 5 = 1.
[5] Undernourished (weight-for-age ≤ −1 SD) = 0, adequately nourished (weight-for-age > −1 SD) = 1.
[6] Control = 0, breakfast = 1.
[7] $P = 0.054$.

(grades 2 and 3) also improved in arithmetic. The internal validity of the study was strong because of the randomized, controlled design in which equal numbers of children were assigned to receive breakfast or a placebo within each school and class. The testers were blind to the children's group and the control children received the same attention as the treatment group, although the piece of fruit that they were given was not a true placebo. This is the first long-term, randomized, controlled breakfast trial that we are aware of from a developing country.

The improvements in the children's nutritional status indicated that providing breakfast increased their dietary intakes. In addition, the children reported that they continued to eat their usual breakfasts at home and they were observed to bring the same amount of money to school as did the control group. We observed the food eaten at a midmorning break and at lunchtime by the children in grades 2 and 5. The breakfast group consumed an average of 227 kJ (54 kcal) less at lunchtime than did the control group, suggesting that a small amount of substitution took place (24). However, this decrease was much less than the content of the breakfast, resulting in a net increase in energy intake.

When the children's scores were converted into grade levels according to North American test standards, the mean grade levels were low and the deficits increased as the children progressed through school. Although the WRAT has not been standardized for Jamaica, it is reliable and predictive of teachers' ratings of children's ability in this population. Furthermore, Jamaican children in more privileged schools score at or above the test standards (19), suggesting that the low scores in the present study reflected poor home and school conditions and the possible detrimental effects of poor health and nutrition. Although the improvement in arithmetic as a result of breakfast was small, the increase represents ≈30% of the average yearly progress. Thus, it is likely that if the school conditions had been better, breakfast would have produced more benefits. This hypothesis is supported by a previous Jamaican study in which benefits of breakfast to the children's behavior varied according to classroom conditions (8). The benefit in arithmetic could have been due to the relief of short-term hunger (5) or it could have been due to the improved nutritional status of the children.

Breakfast resulted in small improvements in the children's attendance. Poor attendance is a major problem in Jamaican schools and undoubtedly contributes to the poor achievement levels (17–19). Improved attendance over longer periods of time should, therefore, further benefit children's achievement levels.

Children receiving breakfast gained on average an additional 0.25 cm during the 8 mo of the intervention, or, by extrapolation, ≈0.4 cm/y compared with children in the control group. This is equivalent to ≈1 mo of growth for children in this age range in the NCHS reference population (15). It could be postulated that if the children gained an extra 0.4 cm/y as a result of the breakfast program, they could accumulate an additional 2.4 cm during their primary school years if the improved growth rates were sustained. This is about one-third of an SD in height-for-age for an 11-y-old child, the age at which most children leave primary school. The increase in weight was equivalent to a 2–3-mo weight gain in the NCHS reference population. Thus, the gain in weight was relatively greater than that in height, leading to a small increase in BMI in the children who received breakfast.

It has been debated whether stunted children can achieve catch-up growth after the age of 3 y. Adoption studies suggest

TABLE 4
Multiple regression analyses of height, weight, and BMI at the end of the intervention, controlling for the children's initial measures[1]

	Height (cm)	Weight (kg)	BMI (kg/m^2)
Age	0.01 (0.01)[2]	0.003 (0.004)	0.004 (0.001)[2]
Sex	0.43 (0.09)[2]	0.40 (0.09)[2]	0.10 (0.04)[2]
Treatment group	0.25 (0.09)[2]	0.42 (0.09)[2]	0.16 (0.04)[2]
Nutrition group	0.77 (0.14)[2]	0.22 (0.15)	0.18 (0.05)[2]
Initial measure	0.98 (0.01)[2]	1.08 (0.02)[2]	0.98 (0.02)[2]
Housing rating	−0.07 (0.03)[2]	—	—

[1] Coefficient; SE in parentheses. Sex, treatment group, and nutrition group were coded as in Table 3.
[2] $P < 0.05$.

that an improved environment can lead to catch-up growth during the school years (25, 26). However, when children remain in poor environments little catch-up growth usually occurs (27). Our results and those of others (28) suggest that improvements in health and nutrition can lead to improved growth in later childhood.

The children in this study were not severely undernourished; however, their nutritional status improved while receiving breakfast, suggesting that school feeding programs could be an effective way of improving nutritional status in countries where undernutrition is a serious problem. The challenge in large programs is to ensure that food deliveries are sufficient and regular.

Unlike in previous studies of the effects of breakfast on cognitive function (5–7), the undernourished group in the present study did not benefit more from breakfast than did the adequately nourished group. This anomaly may have been because the children in the present study were only moderately undernourished. Also, cognition is only one of many factors that influence school achievement; family and school factors are also important (29). However, the undernourished children had poorer achievement levels and came from poorer homes than did the well-nourished children, which is a common finding in many countries (30). It would therefore be appropriate to target undernourished children for school meals where resources are too limited to feed all children. There is some suggestion from our findings that younger children may benefit most from school meals and could also be considered for targeting where resources are limited.

In conclusion, providing breakfast benefited the children's school attendance, achievement, and nutritional status. However, in many developing countries, schoolchildren suffer numerous health and nutritional problems and schools often lack basic amenities, all of which may affect a child's ability to learn. Thus, integrated interventions, which include health, nutritional, and educational components, are required for children to benefit fully from education and for investments to be maximized.

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