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Cognitive and behavioural effects of a school breakfast

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The cognitive and behavioural effects of a school breakfast were explored in a study of 55 children in Grade II and Standard 1 at a farm school outside Johannesburg. A previous study had confirmed widespread undernutrition and micronutrient deficiencies among the children. For comparative purposes, 55 children at an inner-city school, among whom no signs of undernutrition were found, were assessed in the same way. Three different types of measures of attention, distractibility, short-term memory and activity level were used: psychometric testing of the children, teacher ratings of children's classroom behaviour, and coded video-recorded classroom behaviour. A pre- and post-test design was employed to assess the effects of a school breakfast, continually in place in the experimental school for a period of 6 weeks. The results indicated significant change from pre- to post-test assessment among the experimental children in respect of the psychometric measures, teacher-rated hyperactivity and video-recorded classroom behaviour. With regard to the latter measure, the children showed a decline in both the occurrence and duration of off-task and out-of-seat behaviour, and an increase in active participation in class and positive peer interaction. While the children in the comparison group also showed some changes from pre- to post-test, probably attributable to the effects of observation, familiarity with the test materials and developmental change, the changes were not generalised or consistent. The findings support the conclusion that a school breakfast programme had a beneficial effect on the cognitive and behavioural performance of socially disadvantaged, undernourished children in their first 2 years of school.

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It has been forcefully argued[1] that concurrent illnesses and poor nutrition interfere with the schooling of children in low-income countries, and that children's health issues need to be addressed as part of educational interventions. Some of the health and nutrition problems that contribute to the poor performance of children at school are chronic protein-energy malnutrition, iron-deficiency anaemia, iodine deficiency and intestinal helminth infection.[2]

Mild-to-moderate protein energy malnutrition is significantly related to cognitive development and has been found to be associated with a slower learning pace, as well as absenteeism from school.[3,4] Iron deficiency anaemia has been found to result in fatigue and poor concentration, and to be related to poor performance on mental and motor tests among babies and children.[1,4,5] Iodine deficiency can cause mild-to-severe intellectual retardation,[4] and undernutrition has been reported to impact negatively on cognitive functioning and social behaviour.[6]

While a general claim has been made that supplementary nutrition and school feeding can improve the nutritional status of schoolchildren,[7] as well as improve growth and educational performance,[8,9] few controlled studies have been reported which demonstrate these effects unambiguously.[10] Radzikowski and Gale[11] concluded from a review of studies evaluating aspects of the USA National School Lunch Programme that the results were difficult to interpret unambiguously since the variety of factors other than programme participation that might influence outcomes had not been controlled.

Studies in developing countries have experienced many problems in trying to isolate the effects of school feeding from other socio-economic, cultural and educational factors.[12,13] In developing countries, evaluations also have to take account of the fact that food distribution programmes, including school feeding, are not always sufficiently well implemented to show beneficial effects, given problems of, *inter alia*, supply, administration, storage and delivery.[14]

Proponents of school-feeding programmes argue that such programmes may have numerous benefits. Firstly, for many reasons, children from poor families or marginal communities are frequently absent from school and this reduces the likelihood of their profiting from educational activities. School feeding may amplify the motivation of families to send their children to school, and the motivation of children to attend school.[15] Secondly, even in developed countries, nearly one-third of children do not have breakfast regularly[16] — and the figure is probably much higher among poor groups in developing countries. The latter children may also not have had a substantial or nourishing supper the night before. As a result, these children may be hungry during the morning and even hypoglycaemic. This hungry state reduces their ability to pay attention, concentrate, learn and remember and thereby diminishes the benefit of their attending school.[10] In South Africa, for instance, Jooste *et al.*[17] found that nearly one-quarter of the children they studied did not routinely have breakfast and about the same number reported that they were hungry when they came to school. Poor children may also have specific micronutrient deficiencies, particularly iron deficiency anaemia, which is known to affect cognitive functioning.[18,19] School feeding is, in addition, often linked to other economic objectives, like stimulating local agricultural activity or creating employment opportunities for intermediaries.[15,20] Lastly, in countries with widespread hunger and malnutrition, other positive effects of

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school feeding are also anticipated, e.g. beneficial spin-offs from intervention *per se*, increased nutrition knowledge and local food use.[21]

Protein energy malnutrition is a significant problem in South Africa and approximately one-third of black children are estimated to suffer from undernutrition as is manifested in their slower growth.[22] However, since many factors in addition to food intake are related to malnutrition and because stunting in children results from long-term deficiencies, food provision to schoolchildren as an effective means of addressing undernutrition in South Africa is under debate.[21,23] In a recent evaluation of a privately funded school lunch programme for undernourished South African children, it was found that malnutrition continued to be present in unacceptably high rates.[24]

The motivation for the present study stemmed from the current debate about the benefits of school feeding, together with the recently implemented school-feeding scheme in South Africa, the Primary School Nutrition Programme. The need to develop and test measures of children's cognitive and behavioural states, in addition to evaluating the effect of interventions, served as a further motivation for the study.

Method

Design

Because of the faster rate of growth and consequent increased nutritional demands of younger children, as well as an increased adaptation to nutritional levels at older ages, it is probable that the younger the children, the more likely they are to benefit from school feeding. For this reason, and allowing for increased scholastic demand after the first year of schooling, pupils in their second and third years at school (Grade II and Standard 1) were chosen for inclusion in the study.

Children attending a farm school outside Johannesburg, the experimental group, were examined in respect of a number of psychological measures prior to the introduction of a school breakfast, which was supplied to all children at the school. The children were re-examined in respect of the same measures approximately 6 months into the intervention. The post-assessment was scheduled to occur after a period during which the school breakfast had been continuously in place for 6 weeks without interruption by school holidays. No other school-based dietary or health-related intervention occurred during the same period as the pre-assessment, intervention implementation and post-assessment. A second group of children, from an inner-city Johannesburg school, were used as a comparison group. These children were examined with the same psychological measures as the experimental group, and within the same time period. They were also re-examined 6 months later, but did not receive a school breakfast. The research design thus consisted of pre- and post-intervention measures among an experimental group, with each child serving as their own control. In addition, a comparison group of children was also examined during the same time period, and this group provided information about performance increments due to learning, development and intervention *per se*.

Subjects

One hundred and eight children participated in the study — 55 in the experimental group and 53 in the comparison group. The sample consisted of the full classes of children in the two standards at the experimental and comparison schools for whom complete data were available. In the experimental group 28 of the children were male and 27 female; in the comparison group, 26 of the children were male and 27 female. Thirty Grade II children and 25 Standard 1 children from the experimental group were included in the sample, together with 27 Grade II children and 26 Standard 1 children from the comparison group.

The experimental children were significantly older than the comparison children ($t = 7.9$; $P < 0.001$); the mean age of the experimental group was 10.5 years (SD = 1.9; range 7 - 14 years), while the mean for the comparison group was 8.3 years (SD = 0.8; range 7 - 10 years). The children in the comparison group were appropriately aged for their school standard (between 7 and 8 years in Grade II and between 9 and 10 years in Standard I); however, the children in the experimental group showed a very wide range for school standard and were, in general, a year or more older than is accepted as appropriate for the particular school standard. The age range of the experimental group is typical of most black schools in rural areas, however, and demonstrates many of the problems of historically black education — late school enrolment, inconsistent school attendance, very high failure rates in the first 3 years of school, and the lack of facilities for children with special needs who are kept in ordinary classes by default.[25]

Previously published research on the nutritional status of children at the experimental and comparison schools, in the same age range as the children included in this study, also indicated significant differences between them. Reitsma *et al.*[24] examined 50 children (20 boys and 30 girls) randomly selected from the 126 children aged 7 - 12 years in the experimental school, and data from similar evaluations have been reported by Vorster *et al.*[26] for 57 8 - 10-year-old boys in the comparison school. The nutritional status of the children in the two schools was assessed with a dietary survey (24-hour recall and diet history), clinical observations, anthropometry (height, weight, mid-upper arm, waist and hip circumference, and triceps and subscapular skinfolds) and biochemical analyses (protein, lipids, iron status variables, enzymes, minerals, electrolytes and excretion products). In summary, 12% of the children in the experimental school were found to be below the 5th percentile of height-for-age and 18% under the 5th percentile of weight-for-age. The daily energy intake of all the children was also below the recommended daily allowance, as was their intake of calcium, iron, zinc and a variety of vitamins. Clinical examinations indicated that approximately 20 - 25% of children showed signs of malnutrition, including spongy and bleeding gums and muscle wasting. Information obtained from the dietary histories of the children indicated that few received a nutritious meal at home. In contrast, no signs or symptoms of malnutrition were found among the children attending the comparison school.

A school lunch programme has been in operation at the experimental school since 1990 and the data reported here were recorded from children who were participating in that

programme. The specific additional intervention evaluated in this study was the school breakfast.

Measures

In the short term, undernutrition is associated with energy depletion and metabolic disturbances. Attention deficit, distractibility and impulsivity are behavioural symptoms of chronic energy deficits.[27] Activity, attention, alertness and distractibility were the constructs of interest in the present study as they are believed to be related to learning capacity. To some extent the selection of tasks for assessment in the present study was guided by prior research and available theoretical models. For example, visual recall, digit span and clerical tasks have previously been used with some success in studies of the effects of iron deficiency anaemia on cognition.[28] Similarly, Raven's coloured progressive matrices and classroom observation,[29] as well as Wechsler Intelligence Scale for Children (WISC) coding and digit span,[30] have been used in other studies evaluating the effects of nutrition on mental performance. Vigilance, as a standard measure of attention, was also included, as was a teacher rating scale intended to assess activity level in the classroom. A brief description of the measures is given below.

Raven's coloured progressive matrices (CPM)

CPMs were applied as a measure of general non-verbal intelligence in all children pre-intervention. It was not repeated. The CPM was designed for use with, among others, young children and has been shown to be useful with people who, for any reason, cannot understand or speak English. It is a non-verbal measure of intellectual ability, specifically in the realm of abstract thinking, and is believed to be one of the best single measures of 'g' or general ability.[31]

WISC coding A and B and digit span

The WISC coding and digit span are supplementary tests to the basic WISC.[32] Reviews[33] suggest that the abilities associated with WISC digit span performance are attention, auditory memory, concentration, freedom from distractibility, sequencing and short-term memory. Coding performance has been suggested to measure, among others, attention, freedom from distractibility, psychomotor speed, short-term memory, visual-motor co-ordination and ability to work under pressure.

Vigilance task

Attention usually refers to an operating state of arousal (intensity) as well as to selectivity. Vigilance is one aspect of arousal or attentional intensity and is studied by requiring individuals to remain alert to the occurrence of a target, frequently in the context of noise (or distracting information). In this test, designed specifically for the study, children were required to cross out a single letter (an X) in complex arrays of increasingly similar letters in seven stimuli presentations, within a predetermined time limit. The design of the 7 items was suggested by the vigilance-scanning task used by Soemantri *et al.*[34] which they proposed as a measure of attention maintenance and discrimination.

The Attention Deficit Disorder — Hyperactivity (ADD-H) Comprehensive Teacher's Rating Scale (ACTeRS)

This is a teacher rating scale designed to systematise observations of a child's behaviour in primary school.[35] The scale consists of 24 items divided into four sub-scales: attention, hyperactivity, social skills and oppositional behaviour. In rating an individual child, the teacher is asked to compare the child's behaviour with that of their classmates.

Coding of videotaped classroom behaviour

A Sony 8 colour camera with a wide-angled lens was installed on a wall mount in each of the classrooms. Camera placement was carefully determined to afford maximal observational coverage of the classroom. The camera was operated by a remote control device and the camera mount was electrically driven by a motor with a variable panning function set at 10 seconds. With the movement of the camera, each child was visible for a period lasting 2 - 4 seconds, previously ascertained to be long enough to code a child's behaviour along several dimensions.[36] For 1 week the camera was positioned in each class during both the pre- and post-test recordings and switched on, but no filming was done; this was to allow children to become accustomed to the presence of the camera. Rated recordings were made during the subsequent week.

All coding was based on observations of children only while they were engaged in structured or supervised activities. The observational data on each child used for the statistical analysis were selected from the pre- and post-intervention recordings to ensure that the recordings were made on the same day of the week and during the same kind of teaching and classroom activities. With this method, it was possible to select about 100 observations for each child.

Six overlapping categories were used to describe each child's behaviour during each sampled observation period. These were 'on- and off-task', 'passive-active', 'positive or negative peer interaction', 'class participation', 'out-of-seat behaviour', and 'request attention'. Codes were also assigned for 'cannot say' (the child was visible but no definitive behaviour categorisation could be made) and 'out of view' (the child could not be seen during that 10-second interval). Complete agreement between raters on allocating behaviour to the various categories was required during the development phase of the coding system and while interrater reliability was established. The data were subsequently analysed using standard scores for each child. These scores were expressed as the percentage of the total observations possible for the child. In addition, a duration score was computed which reflected the mean number of observations during which any code was assigned, to indicate that a behaviour was present on a continuous basis.

Home interviews

A structured interview with one or more of the primary caregivers of each child was conducted by the child's class teacher. The interview covered information like the child's birth date and position in the family, household density, parental educational and income levels.

School attendance and school results

This information was taken from the class records and results were recorded as a simple 'pass' or 'fail'.

Procedure

Each child was assessed individually in as private a space as possible. Every effort was made to minimise distractions and to ensure that each child understood the instructions and felt at ease with the tester. The Raven's CPMs were administered to all children at the beginning of the study as a measure of non-verbal general intelligence. The digit span, coding, vigilance task, ACTeRS and video-recorded classroom behaviour were the measures of intervention effects before and after the introduction of the breakfast. The psychometric testing was done by three psychologists.

Breakfast

The Kellogg Company of South Africa (Pty) Ltd provided the breakfasts. These consisted of 30 g Kellogg's corn flakes served with 100 ml skim milk and a banana.

Results

Subjects

As can be seen from Table I, the experimental group was disadvantaged relative to the comparison group in respect of a number of social parameters, including household density, the number of children in the family, maternal and paternal educational levels, maternal and paternal occupational categories and household income. The differences between the two groups on measures of parental socio-economic status are particularly marked. No child participating in the study at the comparison school had failed the school year, as opposed to nearly a quarter of the children in the experimental school.

The Raven's CPMs showed that all the children in the experimental group were classified at the lowest end of the continuum on non-verbal intellectual performance (< 25th percentile); in contrast, the comparison group showed a more normal distribution of performance levels, albeit slightly shifted to the lower end of the scale (49% below the 25th percentile). These results, in conjunction with the comparatively prejudiced social environments and poor nutritional levels of the experimental children, indicate that educational intervention among the experimental group is justified.

Pre- and post-intervention psychometric measures

The pre- and post-intervention psychometric assessments were examined in two ways: (*i*) by contrasting the mean performance of the experimental and comparison groups, at the initial assessment and then on follow-up; and (*ii*) by calculating mean individual change scores[37] for the experimental and comparison groups. Results are designated as statistically significant, using *t*-tests for dependent or independent samples as appropriate, at a 1% level of significance.

Table I. Social characteristics of the experimental (*N* = 55) and comparison (*N* = 53) groups

Measure	Statistical test	Experimental group	Comparison group
Household density	$t = 4.01$*	3.6 (1 - 11; *SD* = 2.1)	2.2 (1 - 5; *SD* = 0.9)
No. of children/family	NS	3.5 (1 - 8; *SD* = 1.6)	2.4 (1 - 8; *SD* = 1.2)
Child position/family	$\chi^2 = 12.1$†		
Oldest		22%	56%
Middle		39%	18%
Youngest		39%	26%
Mother living at home	NS	96%	100%
Father living at home	NS	71%	58%
Mother's education	$\chi^2 = 71.6$‡		
None		19%	0
Primary school		71.5%	4%
Secondary school		9.5%	84.5%
Tertiary		0	11.5%
Father's education	$\chi^2 = 46.0$‡		
None		13%	0
Primary school		48.5%	2%
Secondary school		38.5%	75%
Tertiary		0	23%
Mother's occupation	$\chi^2 = 74.4$‡		
Unemployed		16%	31%
Unskilled		84%	0
Semi-skilled		0	10%
White collar/professional		0	59%
Father's occupation	$\chi^2 = 37.2$‡		
Unemployed		11%	8%
Unskilled		50%	0
Semi-skilled		39%	42%
White collar/professional		0	50%
Household income	$\chi^2 = 58.1$‡		
0 - R499		57.5%	4%
R500 - R1099		32%	14%
R1100 - R1499		10.5%	16%
R1500 - R1999		0	22%
R2000 +		0	44%

* $P < 0.05$.
† $P < 0.01$.
‡ $P < 0.001$.

The results indicated the following:

1. Both the experimental and comparison group children showed a mean overall statistically significant improvement in performance from pre-intervention testing to post-intervention assessment on overall score and time on WISC coding A and B and on the vigilance task.
2. On the digit span test the experimental group, but not the comparison group, showed a significant improvement from pre- to post-test, i.e. the experimental group showed a significant difference between pre- and post-test results on both the vigilance task and the digit span test.

Mean individual change scores are shown in Table II. Although the experimental group showed a slightly higher mean change score across all the measures, the difference between the experimental and comparison group on the coding test was not statistically significant. On both digit span and the vigilance tests, the experimental children improved more from pre- to post-test than did the comparison children.

Table II. Mean change scores

Group	WISC-A	WISC-B	WISC Digit	Vigilance
Experimental group	5.78	6.82	1.14	1.14
Comparison group	4.06	6.81	0.44*	0.44*
	NS (t = 1.03)	NS (t = 0.05)	(t = 2.7)	(t = 2.7)

* $P < 0.01$.

Teacher ratings of classroom behaviour (ACTeRS)

Class teachers rated the children's customary classroom behaviour on the ACTeRS scale before the intervention (for the experimental and comparison children) and after the intervention (for the experimental group only). The ratings are shown in Table III. There was only one statistically significant change in the rated behaviour of the experimental group of the children from pre- to post-intervention assessment — hyperactivity declined significantly. Hyperactivity, as rated on the ACTeRS, refers to negative or disruptive behaviour. The five items included in the scale are: extremely overactive; overreacts; fidgety; impulsive; restless.

Table III. Teacher ratings — ACTeRS

Group and measure mean (SD; N; range)	Pre-intervention	Post-intervention
Experimental	20.9	204 NS (t = 0.4)
Attention	(5.2; 52; 9 - 30)	(6.2; 51; 7 - 30)
	11.3	7.5* (t = 6.4)
Hyperactivity	(3.2; 52; 5 - 17)	(2.8; 51; 5 - 19)
	24.8	25.04 NS (t = 0.3)
Social skills	(4.1; 52; 12 - 32)	(4.5; 50; 15 - 34)
	7.4	7.4 NS (t = 0.1)
Oppositional	(2.1; 52; 6 - 15)	(1.6; 51; 6 - 13)
Comparison	23.6	
Attention	(6.2; 52; 9 - 30)	
	10.9	
Hyperactivity	(4.4; 53; 5 - 24)	
	26.7	
Social skills	(6.8; 53; 12 - 35)	
	10.1	
Oppositional	(4.9; 53; 6 - 25)	

* 1% level of significance.

Videotaped and coded classroom behaviour

Two sets of scores were derived for the coded classroom behaviour. The first set consisted of observations in each coding category expressed as a percentage of the total observations for each child — % occurrence. The second set consisted of the mean number of observation periods during which a particular behaviour code was scored as present on a continuous basis — duration. Because of the low level of occurrence of some code categories, duration scores were only calculated for on- and off-task, activity level and peer interaction. In both sets, the scores were derived for pre- and post-intervention observations, and the number of observations made of a particular child during the pre- and post-intervention observations was equalised by adjusting to the maximum possible number for either of the observation periods. Statistical tests indicated to be significant were accepted at a 1% level of significance. The results are given in Tables IV and V.

In general, the experimental rather than comparison children showed significant changes in % occurrence from pre- to post-testing. They showed a decline in off-task and out-of-seat behaviour and an increase in activity, positive peer interaction and class participation. The only exception was on-task behaviour, a category in which the comparison children showed a significant decrease from pre- to post-test.

On the duration scores the experimental children again evinced more change than the comparison children — showing a significant decline in the duration of off-task behaviour and an increase in the duration of active episodes. The duration of the on-task episodes of comparison children showed a significant decline from pre- to post-test. The decline in both occurrence and duration of on-task behaviour among the comparison group is difficult to explain; however, unnoticed changes or unrecorded changes in classroom or teaching conditions could have influenced the children's behaviour.

Table IV. Occurrence of coded videotaped behaviour (%)

Group	Pre-test Mean (SD)	Post-test Mean (SD)	Change Mean (SD)
On-task			
Experimental	68.3 (17.9)	69.9 (16.2)	1.6 (17.8)
Comparison	63.0 (13.0)	57.4 (16.4)	5.64 (18.5)* (t = 3,1)
Off-task			
Experimental	16.05 (10.8)	5.9 (5.4)	10.07 (12.8)*
Comparison	18.3 (8.5)	21.8 (9.1)	3.5 (10.9) (t = 4.5)
Active			
Experimental	0.7 (1.7)	4.8 (5.2)	4.1 (5.5)*
Comparison	2.4 (5.2)	1.6 (3.2)	0.8 (4.4) (t = 4.2)
Passive			
Experimental	0.69 (1.9)	1.04 (2.1)	0.34 (2.7)
Comparison	0.15 (1.99)	0.7 (1.5)	0.51 (1.7)
Positive peer			
Experimental	5.4 (6.9)	1.6 (3.02)	3.8 (7.9)*
Comparison	11.8 (4.9)	9.4 (6.4)	2.3 (8.01) (t = 2.7)
Negative peer			
Experimental	0.05 (0.2)	0.02 (0.12)	0.03 (0.25)
Comparison	0.15 (0.5)	0.96 (2.3)	0.80 (2.3)
Class participation			
Experimental	3.3 (5.4)	9.6 (7.2)	6.3 (10.9)*
Comparison	0.1 (0.3)	0 (0)	0.1 (0.3) (t = 3.2)
Out of seat			
Experimental	2.4 (5.2)	0.3 (1.3)	2.1 (5.4)†
Comparison	2.3 (4.5)	2.8 (4.8)	0.5 (6.5) (t = 2.2)
Request attention			
Experimental	0 (0)	0.1 (0.3)	0.1 (0.3)
Comparison	0.1 (0.2)	0.2 (0.4)	0.1 (0.3)

* 1% level of significance.
† 5% level of significance.

Table V. Duration of coded videotaped behaviour

Group	Pre-intervention Mean (SD)	Post-intervention Mean (SD)	Change Mean (SD)
On-task			
Experimental	13.5 (17.8)	16.6 (18.8)	3.1 (26.6)
Comparison	8.5 (4.1)	6.0 (3.8)	2.5 (5.5)* (t = 2.6)
Off-task			
Experimental	1.9 (1.1)	1.2 (0.7)	0.75 (1.3)*
Comparison	2.7 (1.9)	2.5 (0.9)	0.2 (1.77) (t = 3.4)
Active			
Experimental	0.34 (0.7)	107 (1.9)	1.4 (1.9)*
Comparison	0.7 (0.8)	0.7 (0.9)	0.03 (0.9) (t = 4.1)
Passive			
Experimental	0.2 (0.5)	0.5 (0.9)	0.3 (1.06)
Comparison	0.2 (0.8)	0.7 (1.7)	0.6 (1.96)
Positive peer			
Experimental	1.1 (0.9)	0.8 (0.7)	0.3 (1.3)
Comparison	1.9 (0.7)	1.5 (0.7)	0.3 (0.7)
Negative peer			
Experimental	0.6 (0.2)	0.03 (0.2)	0.03 (0.3)
Comparison	0.1 (0.4)	0.3 (0.5)	0.2 (0.7)

* 1% level of significance.

Absenteeism

There were no apparent intervention effects on absenteeism among the experimental group. If anything there was a slight increase in absenteeism in the experimental school Grade II class in the fourth term when the breakfast was introduced, as compared to terms two and three. In Standard 1 there was a decrease in absenteeism during the fourth term, when the intervention took place, in comparison to terms two and three, but the difference was not statistically significant.

Interrelationships between variables

Pearson product-moment correlations were computed to examine some of the relationships between sets of variables included in the study, notably socio-demographic data, psychometric test results, teacher ratings, videotaped observations of classroom behaviour and change scores. Only the correlations that were statistically significant at the 1% level of probability are reported here.

Sociodemographic data

As was to be expected, child age was associated with a number of the psychometric measures assessed in the combined experimental and comparison groups. This included Raven's CPM (r = 0.5), WISC coding A and B (r = 0.24 and 0.31 respectively), WISC digits total (r = 0.24) and vigilance task performance (r = 0.46). Older children understandably performed better on these tests than did younger children. Age was also related to some of the observed classroom behaviour; for example, younger children were observed to show a higher occurrence of off-task behaviour than older children (r = 0.44) as well as a higher rate of peer interaction (r = 0.33).

Parental socio-economic status, as indexed by parental education, occupation, income level and household density, was significantly related to a number of measures of performance included in the study, particularly psychometric test scores. Table VI shows that children from families of higher socio-economic status performed better on most of the psychometric measures and also engaged in more peer interaction, as assessed pre-intervention, than children from lower socio-economic status families.

Table VI. Relationships between measures of socio-economic status and child assessment

Performance	Maternal education	Paternal education	Income	Household density
Raven's CPM	0.59	0.41	0.49	−0.32
Digits total (pre-test)	0.4	0.3	0.3	-
Vigilance (pre-test)	0.3	0.23	-	−0.21
Peer interaction (pre-test)	0.27	0.47	0.26	-

Psychometric tests, teacher ratings and behaviour observations as measures of the constructs tested

While there were very high correlations among the various psychometric tests themselves, there were only scattered significant relationships between psychometric test results and videotaped classroom behaviour. For example, digit span performance was negatively associated with overactive behaviour in the classroom (r = −0.49) and with off-task behaviour (r = −0.37). The same scattered kinds of relationship pertained between the psychometric tests and teacher-rated classroom behaviour. For example, apart from a significant negative correlation between digit span and teacher-rated hyperactivity (r = −0.34), no other systematic relationships were found. In general, the psychometric tests, the classroom observations and the teacher ratings seemed to be tapping different dimensions of children's behaviour at school.

Change scores

Change scores derived from the psychometric measures, teacher ratings of behaviour and videotaped behaviour observed in the classroom, were correlated with the sociodemographic variables and the pre- and post-intervention measures. Pre-intervention measures, in most cases, accounted for substantial proportions of the variance of change scores: for example, 58% of coding A mean change score, 60% of vigilance change score, 40% of teacher-rated attention, 32% of observed passivity, and so on. In general, the lower a child's score at pre-test, the greater the change in score from pre- to post-intervention assessment. This flattening of effect at higher levels of pre-test performance was not due to the inhibiting effects of an upper limit on the measuring instruments. The measuring devices had the capacity for additional change, but there was a threshold over which children at this age and developmental level did not show dramatic increases. One interpretation of these findings is that interventions tend to have some specificity, in that they boost the performance of children at the lower ends of the performance spectrum to a greater extent.

Discussion

This study examined the effects of a school breakfast programme on the cognitive performance and school behaviour of a group of socially deprived and poorly nourished children attending a farm school outside Johannesburg. In order to gauge the change likely to be attributable to cognitive growth and development from pre- to post-test, as well as test learning, a comparison group of children at a multiracial inner-city Johannesburg school were also assessed at the pre- and post-test points, although the comparison children did not receive the school breakfast. In fact, the two groups of children were not comparable, either socially or cognitively.

The relationships found between socio-economic status and children's performance on the psychometric procedures provide some evidence for the validity of the measures. Some of the measures obtained through psychometric testing, teacher rating and coded behaviour observed in the classroom, suggest positive benefits to children in the experimental group associated with the intervention. In terms of change or difference scores, the experimental group children showed a higher degree of improvement than comparison children on a number of measures, including WISC digit span and the vigilance task. Similarly, experimental group children also showed significant changes from pre- to post-intervention assessment, relative to comparison group children, on the measures of observed classroom behaviour. For example, experimental children showed significantly less off-task behaviour, more participation in classroom activities, less out-of-seat behaviour and a significantly higher occurrence of behaviour rated as active. The teacher ratings indicated that experimental children were not perceived to change in any notable way in terms of attention, social skills, and oppositional behaviour. However, teachers did perceive children in the experimental group to be less hyperactive at post-intervention ratings.

The data obtained offered evidence, even if somewhat qualified, of a beneficial effect on children in the experimental group associated with (but not necessarily attributable to) the school breakfast programme as a nutritional intervention. Measures of attention, short-term memory and focused, involved classroom behaviour indicated that children in the experimental group improved to a greater degree than children in the comparison group; the latter were subject only to the influences of participation in the study and time between pre- and post-testing. This report, however, cannot conclude without doubt that there were cognitive and behavioural benefits for children who received breakfast. There are many technical aspects, including the choice of control groups and nutritional and cognitive assessment procedures, which make the evaluation of school nutrition programmes difficult.[38,39] In this study, the post-intervention performance and behaviour of the children in the experimental school were evaluated in terms of their pre-intervention assessment. In addition, a comparison group was tested in synchrony with the experimental group in order to obtain an estimate of performance increments due to normal developmental processes, familiarity with the measurement tasks and increased effort by the teachers and pupils during the time of the study. All the data available on the two groups of children, though, indicate that they were not comparable and that the experimental group was significantly disadvantaged in respect of both social and nutritional measures. This finding weakened the design of the study. Nonetheless, the study is an important first step in South African work on the evaluation of nutritional interventions among school-aged children. The diversity of measures used raised several interesting questions, including the construct validity of measures of attention, distractibility, short-term memory and so on. Another set of questions raised by the study concern the origin of the range of responsiveness to intervention among the experimental children — some children improved markedly and others hardly at all. Separate, more detailed analyses of the data will be required to address these issues.

There is clearly a need for more knowledge of the intervention effects of school-feeding schemes and cost-benefit analyses of intervention alternatives.[21] The complexity of the social systems into which interventions are placed also needs to be kept in mind. The evaluation of interventions directed at isolated systems in the lives of generally disadvantaged children (unifocal interventions) poses several problems. In many cases, the critical causative pathways involve not only schooling, feeding or after-school care, as examples, but access to resources such as land and income, and exposure to social forces which weaken family coherence. That is, many of the ill-effects that are addressed by specific interventions, such as poor school attendance, high failure rates and so on, are linked to poverty and poverty, in turn, is linked to inequalities of opportunity and power.[40-45] For this reason, discernible effects due to specific interventions are likely to be small. These interventions are classified as 'weak treatments' if they are not accompanied by social development interventions at many levels and if they are not sustained.[46]

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