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Effect of Gender and Nutritional Status on Academic Achievement and Cognitive Function among Primary School Children in a Rural District in Malaysia

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ABSTRACT

Introduction: The aim of this study was to investigate the relationship between gender, birth weight, nutritional status, and iron status of children with their academic performance and cognitive function. **Methods**: Two hundred and forty-nine children, seven to nine years of age, were recruited by systematic sampling from six primary schools in a rural area in Malaysia. Cognitive function was assessed by using Raven's Coloured Progressive Matrices (R-CPM). Academic performance of the children was recorded from their school final examination results in four subjects including Malay language, English, Mathematics, and Science. Birth weight was recorded from the birth certificate, and nutritional status was determined by weight-for-age *z* score and height-for-age *z* score. **Results**: Girls had a significantly higher score in all the academic tests, but a lower cognitive score compared to boys. Nutritional status was found to be correlated significantly with academic performance. Academic and cognitive function scores were also found to be correlated significantly with birth weight, parents' education, and family income. In a multivariate analysis, gender remained the significant predictor of academic function, and iron status and haemoglobin were the significant predictors of cognitive function, after controlling for other variables. **Conclusion**: The study showed that girls performed better academically than boys in rural Malaysia. Nutritional status, parents' education and family income could be additional modifiable factors to improve academic performance of the children. More attention is needed to improve academic achievements of boys at their early school years.

Keywords: Academic performance, birth weight, cognitive function, gender, iron status

INTRODUCTION

Cognitive function can be defined as the person's capacity to acquire and use information to adapt to environmental demands and the process involves many skills including attention, creativity, memory, perception, problem solving,

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thinking, and the use of language (Neisser, 2011). Cognitive function and academic performance of school children can be affected by several factors such as nutritional status, demographics, and socio-economic factors (Anuar Zaini *et al.*, 2005; Zalilah, Bond & Johnson, 2000). Breastfeeding (whether the children were breastfed or not), duration of breastfeeding (Horwood, Darlow & Mogridge, 2001), and facilities available in the school such as teaching materials, and quality of teachers (Ani & Grantham-McGregor, 1999) may also influence cognitive function. Besides the post-natal environment, weight at birth also has an overwhelming influence on cognitive function (Jefferis, Power & Hertzman, 2002) and academic achievement (Breslau, Paneth & Lucia, 2004). Small size at birth has been associated with a range of adverse health outcomes including growth faltering, poor survival, and poor cognitive development (Wilcox, 2001). In poor countries, malnutrition is considered a problem that limits the ability of children to learn and eventually perform at a lower level than well-nourished children in school (Galal & Hulett, 2003).

Nutritional studies in Malaysia show that undernutrition is still a problem in the rural communities especially among young children (Al Mekhlafi *et al.*, 2008). However, limited studies have been conducted in Malaysia on the association between birth weight and the nutritional status of rural children and their academic performance.

There has been a renewed debate on the controversial issue of gender differences on mathematics and science achievement. This debate currently focuses on why women are not seeking careers in information technology occupations. The most comprehensive reviews of the research in the area of gender differences have shown very few true differences between mathematics and verbal abilities between men and women (Halpern, 2000). Gender differences on tests of achievement in reading and mathematics and on tests of cognitive ability have been a popular but an unresolved topic in research on child development (Lummis & Stevenson, 1990).

METHODOLOGY

The aim of this study was to investigate the relationship between gender, birth weight and the nutritional status of rural school children with their subsequent academic achievements and cognitive functions. Our primary objectives were: (1) to determine whether any gender differences exist in school performance and in cognitive function; and (2) to assess the correlation between birth weight and nutritional status with the child's cognitive function and academic achievements. The secondary objectives were to investigate whether: (1) socio-economic environment such as parent's education, and household income directly affect cognitive function and academic achievements; and (2) whether host factors such as breastfeeding at hospital discharge, breastfeeding duration, and iron status influence cognitive function and academic achievements.

Study area and subjects

This cross-sectional study was conducted in the Bachok district, one of the rural areas in Kelantan, located in the east cost of Malaysia. The study included six primary schools selected randomly from a list of schools in the Bachok district of Kelantan, Malaysia. The students were primarily poor Malays who were children of farmers and labourers.

School children, aged seven to nine years old, consisting of 122 males and 127 females, participated in this study. All subjects were selected by using a systematic sampling method with the sampling frame of the total students as listed in the school registry. From the name list, every third student was invited to participate in this study. A total of 420 children were identified and invited to participate. A letter clearly explaining the objectives and research protocol was distributed to the parents through the class teacher. Written informed consent and an assent form were obtained from the parents, and the children respectively, before enrolment could occur. The Human Research Ethics Committee of Universiti Sains Malaysia granted the ethical approval for this study. Permission to conduct the research in the selected schools was also obtained from the Ministry of Education, Malaysia and the Kelantan State Department of Education. Data were collected between May and September 2009.

Structured questionnaire

The parents completed the socio-economic and demographic questionnaires. The information collected included age, gender, ethnic group, number of children, birth order of the child under study, parent's education level, parent's occupation, and household income. Information about birth weight of the child was obtained from the birth certificate or was self-reported by the parents.

Nutritional status

Body weight was measured by weighing the children while wearing school uniforms, but without belts, shoes, and socks, using a digital scale (TANITA Corporation, Japan) with an accuracy of 0.1 kg. Height was measured using a microtoise tape (Seca bodymeter 208, Hamburg Germany) to the nearest 0.1 cm. An average of two measurements of weight and height was recorded. *Z*-scores for weight-for-age, height-for-age, and body mass index (BMI) were calculated by standard methods, and nutritional status of the children was determined according to WHO 2007 growth reference (de Onis *et al.*, 2007).

Iron deficiency anaemia in early life is related to altered behavioral and neural development (Beard, 2003). To determine the effect of anaemia and iron deficiency on cognitive function, blood samples from the study children were tested for haemoglobin (Hb), haematocrit (HCT) and ferritin by standard methods. Serum ferritin values <12 μg/L are considered as iron depletion in young children (WHO, 2011).

Academic achievement

Academic achievement was assessed based on the student's class final test results. Results for Malay language (comprehension), English language, mathematics, and science were obtained from student's academic records for the final examination. A total academic score was calculated by adding all the subject scores. The highest possible score for each subject area and the total was 100 and 400, respectively.

Reliability test for Raven's Coloured Progressive Matrices (R-CPM)

The instructions were translated into the Malaysian language (*Bahasa Malaysia*) and back translated accordingly by experts in this field. The translated R-CPM was pre-tested among 20 children who were not included in the study. Instructions were given to the children according to the standard protocol. A reliability test was done for the instrument used in the R-CPM by using Cronbach's alpha method (Leech, Barett & Morgan, 2007). There were 180 students involved in this reliability test, consisting of students in grades one, two and three from the school in the same locality. Additionally, these students were not included in the final study sample. The Cronbach's alpha values for the subset scores and the overall score for the R-CPM were between 0.70 and 0.87. A value of Cronbach's alpha of 0.70 or higher is considered standard for a good internal consistency of the instrument (Leech *et al.*, 2007). Cronbach's alpha values for the subset scores and the overall score for the R-CPM were within acceptable limits.

Cognitive function

The Raven's Coloured Progressive Matrices (R-CPM) (Raven's Educational: CPM / CVS, 2008) was used to assess the student's cognitive ability. The R-CPM is a measure of non-verbal intelligence. It is used to measure degrees of intellectual maturity by quantifying a child's ability for comparisons and reason by analogy where it measures the individual ability in observation and clear thinking (Raven, 2008). The test has been validated and used previously to assess cognitive ability of school children in Selangor, Malaysia (Anuar Zaini *et al*., 2005). The R-CPM was chosen, as it is a non-verbal test, and, therefore, is least likely to have cultural bias (Anuar Zaini *et al*., 2005). The test was presented as coloured illustrations in a printed book, to attract and maintain children's attention, consisting of 36 items with three sets of 12 items in each (set A, AB, and B). All of the correct answers were added for each set (maximum of 12 points for each set) and for the total score (maximum of 36 points). The final raw score for each subject was standardised to adjust for age, as demonstrated by Raven in the manual (Raven, 2008).

The participants were assessed in a quiet room, such as the school library, an empty classroom, or a laboratory by a clinical psychologist not directly involved in the study. The test was completed by each child in less than one hour

Statistical analysis

All statistical analyses were performed by using Statistical Package for Social Sciences (SPSS), version 18 (SPSS Inc., Chicago, USA). The results are presented either as mean and standard deviation or as proportion. Any significant difference of the outcome variables by gender was assessed by *t*-test, 95% confidence intervals, and chi-square test depending on the nature of the variables. Birth weights were categorised into low (<2.5 kg), normal (2.5 - <4.0 kg) and heavy ($\geq$ 4.0 kg), and one-way ANOVA test was performed to assess if there were any differences of academic test scores and cognitive function scores among the three categories. Tukey's Honestly Significant Difference (HSD) test was done to find out which group is different, if any. Pearson's correlation analysis was used to determine the relationship between nutritional status and birth weight with academic achievement and cognitive function. A multiple linear regression analysis was done to determine the significant predictors of academic achievement and cognitive function. A probability value of 0.05 or less was considered statistically significant.

RESULTS

The study included 249 children, 122 of whom were males, and 127 females. Ages of the children included in the study ranged from 6.2 to 9.8 years, with a mean ± *SD* of 8.01 ± 0.91 years. Table 1 shows that males and females did not differ by birth weight, anthropometric characteristics, socio-demographic characteristics, and breastfeeding status. On average, both parents had the equivalent of ninth grade of education. The average household size was 6.98 ± 1.87 (range, 3 to 13). The mean household income was around RM 1,000 / month (equivalent to USD320 / month). It is noteworthy that the average birth weight of the children was 3.0 kg. About 11% of the study subjects had low birth weight (<2.5 kg), and 3.6% had heavy birth weight ($\geq$ 4.0 kg). More than 96% of the children were breastfed at hospital discharge and more than 87% of the children were breastfed for more than 6 months.

Table 2 shows that the children did not differ by gender in terms of Hb concentration, ferritin levels, iron status and HCT values. Nineteen children (8.7%) had depleted iron stores based on serum ferritin levels of <12 μg / L; 11 of them were boys and 8 were girls. Only one child had Hb $\leq$10 mg / dL, and 44 (20.2%) had Hb <12 mg / dL.

Table 1. Socio-demographic characteristics, anthropometric measurements and birth weight by gender and for combined study population

Characteristics	*Male + Female (n = 249)*	*Male (n = 122)*	*Female (n = 127)*	*P value*
Age (year)	8.01 ± 0.91	8.00 ± 0.90	8.02 ± 0.92	0.90[a]
Birth weight (kg)	3.04 ± 0.49	3.07 ± 0.49	3.01 ± 0.50	0.43[a]
Weight-for-age *z* score	-.93 ± 1.31	-.95 ± 1.46	-.92 ± 1.15	0.88[a]
Height-for-age *z* score	-1.05 ± 0.87	-1.08 ± 0.91	-1.02 ± 0.84	0.61[a]
Body mass index (kg/m^2)	15.49 ± 2.77	15.62 ± 3.03	15.37 ± 2.50	0.48[a]
Father's education (y)	9.02 ± 3.04	9.08 ± 3.13	8.96 ± 2.96	0.76[a]
Mother's education (y)	9.29 ± 3.13	9.53 ± 3.02	9.04 ± 3.23	0.22[a]
Household income (RM/month)	1,005 ± 155	1,002 ± 1317	933 ± 977	0.32[a]
Household size	6.98 ± 1.87	6.80 ± 1.85	7.16 ± 1.88	0.14[a]
Breastfeeding at hospital discharge: No. (%)	241 (96.8)	118 (96.7)	123 (96.9)	1.00[b]
Breastfeeding duration (month)	19.69 ± 9.03	19.26 ± 9.05	20.11 ± 9.04	0.47[a]

[a]Student's *t*-test; [b]Chi-square test.

Table 2. Haemoglobin, ferritin, iron status and haematocrit by gender and in combined study population

Characteristics	*Male + Female (n = 218)*	*Male (n = 107)*	*Female (n = 111)*	*P value*
Haemoglobin (g/dL)	12.70 ± 1.03	12.66 ± 0.83	12.74 ± 1.20	0.58[b]
Haemoglobin <12 g/dL: No (%)	44 (20.2)	21 (19.6)	23 (20.7)	0.87[c]
Ferritin (μg/L)	37.40 ± 21.32	37.87 ± 22.57	36.93 ± 20.13	0.75[b]
Iron deficiency[a]: No. (%)	19 (8.7)	11 (10.3)	8 (7.2)	0.48[c]
Haematocrit (%)	38.73 ± 2.83	38.53 ± 2.18	38.92 ± 3.35	0.31[b]

[a]Serum ferritin <12 µg/L; [b]Student's *t*-test; [c]Chi-square test.

Children with low Hb (<12 mg/dL) had a significantly lower cognitive function score (by Raven's test) (p =0.006) compared with those with normal Hb status ($\geq$12 mg/dL) (Table 3). Similarly, children with depleted iron stores, as measured by serum ferritin of less than 12 μg/L, had significantly lower cognitive function test scores compared to those with normal iron stores. Children with low iron stores and those with normal iron stores also differed significantly on science test scores. No differences were observed in any other academic test scores between the children with or without low Hb or those with or without low iron stores (ferritin levels).

The children differed significantly by gender on all of the major outcome variables,

Table 3. Academic performance and cognitive function by haemoglobin and iron status

Characteristics	*Hb <12 mg/dL*	*Hb ≥12 mg/dL*	*P value*[a]	*Ferritin <12 µg/L*	*Ferritin ≥12 µg/L*	*P value*[a]
Malay language	68.02 ± 21.65	70.34 ± 25.62	0.59	64.63 ± 24.45	70.40 ± 24.88	0.34
English	45.51 ± 20.34	52.57 ± 23.32	0.07	42.84 ± 18.58	51.94 ± 23.13	0.10
Mathematics	47.95 ± 20.95	54.08 ± 25.75	0.11	46.21 ± 19.96	53.52 ± 25.33	0.22
Science	60.31 ± 18.59	65.90 ± 20.81	0.11	55.16 ± 14.53	65.74 ± 20.75	0.008
Total academic	222.50 ± 69.72	243.54 ± 81.50	0.13	208.84 ± 67.29	242.36 ± 80.21	0.08
Raven's test score	78.56 ± 13.08	86.25 ± 16.80	0.006	68.68 ± 14.52	86.26 ± 15.76	<0.001

[a]Student's *t*-test.

Table 4. Gender difference in academic performance and cognitive function scores (mean ± SD)

Characteristics	*Male(n = 114)*	*Female(n = 123)*	*95% Confidence Interval*	*P value*[a]
Malay language	62.72 ± 27.38	74.97 ± 22.09	-18.59, -5.90	<0.001
English	45.81 ± 22.57	55.26 ± 23.11	-15.32, -3.59	0.002
Mathematics	46.96 ± 25.02	57.51 ± 24.20	-16.85, -4.25	0.001
Science	61.12 ± 21.63	67.72 ± 20.19	-11.95, -1.25	0.016
Total academic	217.73 ± 82.73	255.46 ± 76.76	-58.19, -17.28	<0.001
Raven's test	86.59 ± 15.41	82.67 ± 16.67	-0.14, 7.98	0.058

[a]Student's *t*-test.

including academic performance scores of Malay language (p <0.001), English test (p = 0.002), mathmetics test (p = 0.001), science test (p = 0.016), and total academic test scores (p <0.001). Interestingy, the cognitive test scores by Raven's test was lower (p = 0.058) among females, although the academic test scores among females were significantly higher than those of males (Table 4).

Relationship among birth weight, nutritional status, parents' education, income, academic achievement, and cognitive function

A Pearson's correlation shows that birth weight significantly correlated with the child's nutritional status, as determined by weight-for-age z score and height-for-age z score. Scores of academic performance and cognitive function (Raven's test) correlated significantly with birth weight, parents' education, and family income (Table 5). About 4% of our study children were overweight at birth (birth weight ≥ 4.0 kg). The association between academic performance and cognitive function remained the same when such overweight infants were included in the analysis.

When the children were grouped by low, normal, and heavy birth weight, a linear increase in total academic score was observed among the groups, meaning a dose-response relationship. Tukey's HSD test showed that children with heavy birth weight had a 72-point difference in total academic scores compared with low birth weight children (272 ± 64 vs. 200 ± 100, respectively; p = 0.04). However, no

Table 5. Correlation between birth weight, nutritional status, parent's education, family income, and breastfeeding with academic performance and cognitive function

Characteristics	*Malay language*	*English*	*Math*	*Science*	*Total academic*	*Raven's Test*
Birth weight	r = 0.21p = 0.002	r = 0.20p = 0.004	r = 0.18p = 0.012	r = 0.16p = 0.02	r = 0.21p = 0.002	r = 0.16p = 0.024
Height for age	r = 0.16p = 0.014	r = 0.16p = 0.013	r = 0.12p = 0.071	r = 0.10p = 0.133	r = 0.17p = 0.012	r = 0.06p = 0.395
Weight for age	r = 0.17p = 0.009	r = 0.19p = 0.003	r = 0.06p = 0.335	r = 0.07p = 0.268	r = 0.16p = 0.014	r = 0.09p = 0.163
Father's education	r = 0.19p = 0.005	r = 0.26p < 0.001	r = 0.21p = 0.002	r = 0.22p = 0.001	r = 0.24p < 0.001	r = 0.15p = 0.021
Mother's education	r = 0.19p = 0.003	r = 0.19p = 0.005	r = 0.17p = 0.009	r = 0.25p < 0.001	r = 0.23p < 0.001	r = 0.02p = 0.753
Income	r = 0.27p < 0.001	r = 0.28p < 0.001	r =0.29p < 0.001	r = 0.27p < 0.001	r = 0.32p < 0.001	r = 0.14p = 0.034
Breastfeeding at hospital discharge	r = -0.06p = 0.393	r = -0.06p = 0.364	r = 0.00p =0.994	r = -0.06p = 0.355	r = -0.05p = 0.434	r = 0.04p = 0.511
Breastfeeding duration	r = -0.09p = 0.177	r = -0.06p = 0.405	r = -0.12p = 0.078	r = -0.08p = 0.261	r = -0.10p = 0.137	r = 0.02p = 0.728
Haemoglobin	r = 0.04p = 0.59	r = 0.13p = 0.071	r = 0.10p = 0.155	r = 0.11p = 0.114	r = 0.11p = 0.126	r = 0.19p = 0.006
Ferritin	r = 0.07p = 0.336	r = 0.12p = 0.098	r = 0.08p = 0.224	r = 0.15p = 0.031	r = 0.12p = 0.08	r = 0.30p < 0.001

Table 6. Multiple regression analysis to predict academic performance and cognitive function

	Dependent variable: Total academic score			*Dependent variable: Cognitive function*		
Independent variables	*β*	*SE*	*P*	*β*	*SE*	*P*
Gender (1=male, 2=female)	38.69	11.81	0.001	-4.61	2.42	0.059
Birth weight	22.97	12.48	0.068	1.15	2.58	0.658
Height-for-age	-2.37	8.38	0.778	-1.38	1.74	0.43
Weight-for-age	8.62	5.84	0.142	0.74	1.17	0.531
Father's education	1.06	2.25	0.640	0.52	0.46	0.258
Mother's education	2.85	2.63	0.281	-0.25	0.50	0.625
Income	0.012	0.007	0.083	0.002	0.001	0.118
Breastfeeding duration	-0.50	0.68	0.465	-0.01	0.14	0.94
Haemoglobin	5.93	14.92	0.692	9.14	3.10	0.004
Ferritin	19.68	19.37	0.311	16.42	4.04	<0.001
Constant	66.04			31.38		
R^2	0.22			0.23		

significant difference in cognitive function scores was observed among the children in the three birth weight categories.

Height-for-age *z* scores and weight-for-age *z* scores correlated significantly only with the scores of Malay language (comprehension), English language, and total academic scores (Table 5). Hb and iron status (ferritin) were significantly correlated with cognitive function. No significant correlation was observed between the academic performance and cognitive function scores with breastfeeding status or breastfeeding duration.

In order to remove the effect of confounders, variables which correlated significantly with academic performance test scores and cognitive function test scores were entered into models using multiple linear regression tests. Table 6 shows that gender remained the only significant predictor of academic performance, after controlling for other variables. Serum levels of ferritin (a measure of iron store) and Hb status were significant predictors of cognitive function, after controlling for other variables.

DISCUSSION

This study identified a significant gender difference in academic performance of young children. It also confirmed the hypothesis that depleted iron stores and low Hb status decreases children's cognitive function. The academic scores of Malay language, English, mathematics, science, and the total academic score were significantly higher in females than their male counterparts. However, the cognitive function scores measured by Raven's test were 4 points lower, although not significant, in females than males. The phenomenon that boys tend to perform poorer than girls has been noted in other studies. Jefferis *et al.* (2002) showed that math *z* scores increased more in females than in males with an increase in birth weight. Female Malaysian students earn better grades, in general, than male Malaysian students (Kamogawa, 2003). The reason for the poor performance of girls in Raven's test score could be explained by the requirements of the test. Raven's cognitive test depends on non-verbal logical reasoning. Evidence suggests that females have a verbal advantage that extends into numerous tasks, including spatial, verbal, autobiographical, and emotional memory (Andreano & Cahill, 2009). Another more logical explanation could be that female education is now considered a social right and, in particular, has enhanced educational opportunities and support for female Malaysian students over the past few decades (Kamogawa, 2003). More studies are needed to examine if this changing trend in support for female education contributed to academic outperformance of females compared to their male counterparts.

Several nutritional parameters were found to affect directly school performance and cognitive function of the children. Among these variables, birth weight had a strong positive significant correlation with individual subject score, total academic score, and Raven's test score. Low birth weight children had poorer academic performance compared to those with birth weights of more than 2.5 kg. This finding concurs with an earlier study finding of a positive relationship between birth weight and subsequent academic performance of children (Ong, Boo & Chandran, 2001). These authors also showed low birth weight to be associated with lower IQ scores, clumsiness, and behavioural problems among children at 4 years of age. Other studies also confirmed the relation of birth weight on intelligence and academic performance (Rahu *et al*., 2010). The target population of our study although different, showed similar results compared to earlier studies conducted among urban preschool children in a developing country (Santos *et al*., 2008), and in older urban children and young adults in developed countries (Shenkin, Starr & Deary, 2004). In a longitudinal birth cohort study, Jefferis *et al.* (2002) observed a significant improvement in the outcome of all childhood cognitive tests and educational achievements with increasing birth weight. In a meta-analysis of 1,556 cases born preterm and 1,720 controls born at term, Bhutta *et al*. (2002) reported that cognitive test scores significantly correlated with birth weight and gestation at birth. A systemic review by Shenkin *et al.* (2004) also demonstrated a consistent positive association between normal birth weight and childhood cognitive ability, even after controlling for confounders.

A significant linear association of school performance of rural Malay children was shown with their nutritional status. The test scores that were found significantly correlated with height-for-age *z* score and weight-for-age *z* score included Malay language, English language, and the total academic test score; however, no significant association was observed between math score, science score, and Raven's cognitive function score with parameters of nutritional status. Results indicated that nutritional status was only associated with academic performances but not with the cognitive test. Even within the academic test scores, height-for-age and weight-for-age were directly correlated with language test scores of Malay and English but not with math and science scores. The finding that the children's height-for-age was associated with their academic perforamance is in agreement with other studies (Zalilah *et al*., 2000), and this suggests that early nutritional deficit may have persistent effects on children's achievement. Improving the nutrition of pregnant women, infants, and toddlers can prevent stunting and result in better motor and mental development.

The association between Hb and iron status with cognitive function score was significant and strong. Even after controlling for confounders, the variables remained statistically significant to predict cognitive function. In fact, in a previous study reported by the same group (Hamid Jan *et al*., 2010), children with iron deficiency had significantly lower cognitive function test scores compared to their healthy counterparts. After age adjustment, iron deficient children without anaemia scored significantly lower than the healthy children ($p < 0.001$) on coding test, while iron deficient children with anaemia scored significantly lower than their healthy counterparts on the maze test ($p < 0.001$). In another study among 5,398 school-age children and adolescents in the United States, average math scores were lower for children with iron deficiency with or without anaemia, compared with children with normal iron status (Halterman *et al*., 2001). Screening for iron deficiency and anaemia may be warranted for children at risk for poor cognitive function. Earlier therapeutic trails have shown benefits of iron supplementation on improvement of cognitive function in iron deficient children (Bruner *et al*., 1996).

Several studies have documented benefits of breastfeeding on cognitive function of children (Anderson *et al*., 1999). However, we could not assess this relationship because almost all of the participants (241/249) were breastfed at hospital discharge. In this study, some socio-demographic factors, such as parent's education and family income contributed significantly to academic performance and cognitive function of the children. Tong, Baghurst & McMichael(2006) suggested that the detrimental effect of low birth weight on cognitive function may be eliminated by improving socio-economic status, schooling, and nutrition of children. Glewwe, Jacoby & King (2001) showed that a dollar invested in an early childhood nutrition programme in a developing country could potentially return at least three dollars worth of gains in academic achievement, and perhaps much more. In marginally poor populations, socio-environmental factors are likely to play an increasingly important role. Unfavourable socio-economic conditions, poorly educated mothers, absentee fathers, poor sanitary conditions at home and in the neighbourhoods, and low birth weight were negatively associated with cognitive performance of children at five years of age, while strong positive associations were found between high levels of domestic stimulation and nursery school attendance (Santos *et al*., 2008). Hence, a holistic approach involving parents, community, and government agencies is needed in assuring optimum child support and development.

Some study limitations deserve attention for future research. Firstly, this is a cross-sectional study, and academic achievement data did not include academic history. Secondly, the ability to generalise the results of this study could be limited to rural communities in Malaysia, although similar association between nutritional status and academic performance had been reported from urban areas in the country (Anuar Zaini *et al*., 2005).

CONCLUSION

In summary, factors such as gender, birth weight, child nutritional status, parental education, household income, and Hb and iron status were associated with either the academic performance or cognitive function or both of the school children in bivariate analysis. Gender was the single most significant predictor of academic performance, and Hb and iron were significant predictors of cognitive function in children, after controlling for confounders. Measures are needed to alleviate the gender differences in academic performance in rural areas in Malaysia. Children at risk for poor cognitive function should be screened for Hb and iron status for possible interventions.

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