Original Article

Nutrition and educational achievement of urban primary schoolchildren in Malaysia

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The relationship between nutrition, health and educational achievement of school-age population in less developed countries has been of interest to many researchers due to the frequent observation that many children did not complete primary school and those who completed, did not do as well as children in the developed countries. Nevertheless, nutritional and health status by itself is not the only variable affecting educational achievement, since biological, psychological, socioeconomic and cultural factors could directly or indirectly affect both nutrition, health status and educational achievement. The mechanism by which health and nutrition influence educational achievement is not well established, but poor health and malnutrition in early childhood may affect cognitive abilities, necessary for learning process and consequently educational achievement. A study was conducted in Kuala Lumpur, Malaysia, to investigate the relationship between nutritional status and educational achievement among primary schoolchildren from low income households ($n = 399$). A high percentage of them were mild-significantly underweight (52%), stunted (47%) and wasted (36%) and increasingly overweight (6%). In general, more boys than girls were found to experience some form of malnutrition. While weight-for-height did not differ significantly according to family, child and school factors, weight-for-age and height-for-age differed significantly by gender. Also, height-for-age was significantly related to household income. This indicates that stunting may be a consequence of prolonged socioeconomic deprivation. Educational achievement was measured based on test scores for Malay language (ML), English language (EL) and mathematics (MT). While a majority of the schoolchildren obtained optimum scores (>75) for ML and MT, the majority of them had insufficient scores (<50) for EL. Children's total score (TS) for the three subjects was significantly associated with household socioeconomic status, gender, birth order and height-for-age. Even after controlling for household socioeconomic status, significant association between TS and height-for-age persisted. In this sample of schoolchildren, household income, gender, birth order and height-for-age were significant predictors of TS. The finding that height-for-age is related to educational achievement agrees with other studies, which have reported that height-for-age, compared to weight-for-height or weight-for-age is linked to educational achievement. Height-for-age reflects the accumulation of nutritional deprivation throughout the years, which may consequently affect the cognitive development of the children.

Key words: educational achievement, height-for-age, Kuala Lumpur, Malaysia, nutrition, primary schoolchildren.

Introduction

In the developing countries, mortality and morbidity for children aged under 5 years are major concerns, as they are closely related to the general standard of living and whether a population is able to meet its basic needs such as food, housing and health care.[1] School-age children, compared to very young children (under 5 years of age) may not usually experience severe health and nutritional problems. There are few deaths from malnutrition in this age group, because they are able to consume adult foods and have developed immunity to many infections and parasites.[2] Consequently, health and nutritional needs of this age group have been relatively neglected, although many conditions such as nutritional deficiencies, helminthic infections, other infections (ranging from malaria to dental caries), substance abuse, injury and poisoning may generate high levels of illness, even though they are unlikely to cause deaths.[3]

As mortality under the 5 years of age has been greatly reduced in the developing countries, the opportunity for the children to attend school increases. However, it has been reported that incompletion of primary school education by many children and unsatisfactory educational achievement among those who completed their primary years were the major problems faced by the education planners in developing countries.[4] The relationship between poor health, nutrition and educational achievement is poorly understood, although malnutrition in early childhood can have detrimental effects on cognitive abilities necessary to the learning process. Many factors may contribute to educational achievement, but the possible role of nutrition in school performance

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either through effects on school attendance or attention and cognitive abilities.[5] It has also been suggested that malnutrition can result in poor judgement, irritability, moodiness and short attention span that can disrupt the child's learning process.[6] The inability to perform well in schools may also lead to dropping out from schools, which is evident in the low enrolment in secondary schools among children in the less developed countries. Pollitt[7] suggested that poor school performance may act as an intermediary pathway in which common illnesses and malnutrition among preschoolers and school-age children affect dropping out from schools. However, the cause and effect relationship between malnutrition and educational achievement is difficult to establish without taking into consideration the relationship between educational achievement and other factors, such as socioeconomic deprivation, family and school environments and child characteristics.

Several studies have documented the relationship between poor health, nutrition and school achievement. Low anthropometric measurements (height-for-age, weight-for-height and head circumference) have been frequently associated with poor school outcomes.[6,8–14] In fact, in several of the studies, the relationship remained significant, even after controlling for socioeconomic variables.[8–10,14] Iron-deficiency anemia, missing breakfast and helminthic infections have also been reported to affect school performance.[6,14–18] Poor school outcomes may not be direct consequences of poor nutritional and health status, but it may reflect shared contributory factors – poverty and malnutrition. Malnutrition hinders intellectual development and is one of the contributing factors to generally poor school outcomes among children from underpriviliged communities.

The purpose of the study was to investigate the relationship between nutritional status and educational achievement among primary school children in Kuala Lumpur, Malaysia. We also obtained information on family, child and educational achievement. Five research questions were formulated prior to the study:

1. What are the prevalences of underweight, stunting and wasting?
2. Is there any difference in nutritional status by family, child and school factors?
3. Does educational achievement differ by family, child and school factors?
4. Is the relationship between educational achievement and nutritional status confounded by household socioeconomic status?
5. What are the factors that predict educational achievement?

Similar to other less developed countries, health and nutrition of school-age children as related to educational achievement in Malaysia has not received much attention, although the number of primary schoolchildren (7 to 12-year-olds) in Malaysia has increased to approximately 2.9 million.[19] In Malaysia, the yearly primary school enrolment exceeds 95% for both male and female children. However, the number enrolled for secondary school dropped to approximately 60% for both groups. Poor health and nutrition may not be the main reason for the decrease in secondary school enrolment as there are many contributing factors involved. However, it is equally important to know if health and nutrition do contribute to the significant decline in secondary school enrolment in Malaysia, as it has been documented elsewhere that children's health and nutrition play a role in their cognitive development and consequently their educational attainment.[20] It is hoped that findings of this study will assist health and educational officials to prepare for the increasing number of children enrolled in the school system in Malaysia and the rising incidence of health and nutrition problems among this age group. This paper also encourages to focus on measures to eliminate the problems, as they may hinder the government's goal to produce a well-educated nation.

Methods

Study area and subjects

A list of 35 government-owned primary schools that serve low socioeconomic areas in Kuala Lumpur was obtained from the Malaysian Ministry of Education. There were 21 schools with children predominantly from the Malay ethnic group. The remaining 14 schools had children from all of the ethnic groups (Malay, Chinese and Indian). From these 21 schools, four schools were selected based on their vicinities and area representations. These schools represented four different low socioeconomic areas in Kuala Lumpur.

All children in primary 1 in the four schools were included in the study. The age range of the children was 6–8 years. Altogether there were 399 children, with the majority from lower socioeconomic households and all of them were Malays. The field study was carried out from October to December of 1997 and the research protocol was approved by both the Malaysian Ministry of Education and Wilayah Persekutuan Department of Education.

Measurements

Nutritional status. Only height and weight measures were considered for physical stature in this study. The children were weighed on SECA digital scale (Seca, MD, USA) to the nearest 0.1 kilogram. The child's height was measured using a portable infant/adult measuring unit (Perspectives Enterprises, MI, USA) to the nearest 0.1 cm. Age of the child was calculated as the difference between his/her birth date and the date of assessment. It has been proposed that in the assessment of nutritional status in cross-sectional studies, the primary emphasis should be on height-for-age as an indicator of past nutrition and weight-for-height as an indicator of current nutrition.[21] The Z scores for these two nutritional indicators were calculated using the software Epi Info 6.04 (Centers for Disease Control and Prevention, GA, USA).[22]

Each child was then categorized into of the following categories in relation to weight-for-age, height-for-age and weight-for-height: significantly malnourished (< -2 standard deviation (SD) of NCHS reference); mildly malnourished (-2 SD $\leq \times < -1$ SD of NCHS reference) and not malnourished (≥ -1 SD NCHS reference). The National Center for Health Statistics (NCHS/WHO) standard was used to compare the nutritional status of these children.[23] The justification for using NCHS reference population as a comparison was that Malay children (3–12 years) from wealthy families in Kuala Lumpur, Malaysia had similar growth patterns to that of the NCHS population.[24]

Educational achievement. Children's end of the year test scores for Malay language (ML), English (EL) and mathematics (MT) were obtained from their academic records. For ML and EL, these subjects included reading, writing and spelling. The use of these test scores, instead of scores from a standardized or intelligence test is indeed a limitation to the study, because of the variability of the tests among the schools (each school had different sets of test). However, based on a longitudinal study on the effectiveness of school supplementary feeding program in improving school attendance and educational achievement (end of term examinations),[25] discussions with schoolteachers and principals from these schools and also officials from the Malaysian Ministry of Education and Wilayah Persekutuan Department of Education, these tests were sufficient to measure the academic ability of the children. It has also been reported that there is a significant positive relationship between educational achievement and intellectual ability.[13] For the individual subjects and overall results, the highest possible scores were 100 and 300, respectively. The test scores were categorized as the following based on each subject (ML, EL and MT) and the total for the three subjects: optimum achievement (>75 or >225); sufficient achievement (50–75 or 150–225); insufficient achievement (<50 or <150).

Family and child background. General family information such as household income, income per capita, number of children, household size, child's birth order and child's birthdate were obtained from children's schools records and questionnaire. This information was intended to serve as an indirect indicator of household socioeconomic status, child's health, development and predictor of educational achievement.

Statistical analyses

Data processing included Pearson's correlation coefficients, *t*-test and analysis of variance (ANOVA) and analysis of covariance (ANCOVA). Stepwise multiple regression was utilized to yield a combination of factors with greatest explanatory power in predicting educational achievement. All analyses were done using Statistical Package for Social Science Version 7.5 (Norusis, 1997; SPSS, IL, USA).

Results

Family, child and school factors

Table 1 presents the background information of the families, children and schools involved in the study. In this sample, the mean monthly household income was RM1004 (USD1 = RM3.8), which was lower than the average household income reported for the urban Malay (RM2162).[19] However, several studies have reported the average monthly income for the majority of poor urban Malays to be RM300–800.[26,27] Taking the poverty level income in Kuala Lumpur as RM750 for a household of five persons (RM150/person), more than 50% of the families in this study were living in poverty. However, this percentage of people living below poverty line may be inflated, because the families might underreport their actual incomes in the school documents and the research questionnaires. The majority of the households consisted of more than five people which was higher than the average household size of 4.30 reported for households in urban areas of Malaysia.[28]

Nutritional status

In this sample, approximately 52, 47 and 36% of the school children were mild-significantly underweight, stunted and wasted, respectively (Table 2). More male than female children were found to be experiencing some form of malnutrition. In looking at the percentages of children in this sample who had *Z* scores below the median – 1 SD and – 2 SD for weight-for-age, height-for-age and weight-for-height, these percentages exceeded the 'expected' proportion of children

Table 1. Description of the sample by family, child and school factors (*n* = 399)

Factor	*n*	Percent (%)
Family		
Household income (RM) [a]		
1–800	222	55.6
> 800	177	44.4
Income per capita (RM) [a]		
1–150	229	57.4
151–300	120	30.1
> 300	50	12.5
Household size		
1–4	71	17.8
5–7	249	62.4
> 7	79	19.8
Number of children		
1 –3	157	39.3
4–5	164	41.1
> 5	78	19.5
Child		
Male	209	52.4
Female	190	47.6
Birth order		
1–2	180	45.1
3–4	144	36.1
> 4	75	18.8
School		
1	107	26.8
2	96	24.1
3	112	28.1
4	84	21.0

[a] RM1 = USD3.8.

Table 2. Nutritional status of primary school children aged 6–8 years (*n* = 399)

Factor	Total (%)	Male *n* (%)	Female *n* (%)
Weight-for-age			
Significantly[a] underweight	64 (16.0)	(18.2)	(13.7)
Mildly[b] underweight	140 (35.1)	(38.3)	(31.6)
Not underweight	195 (48.9)	91 (43.5)	104 (54.7)
Height-for-age			
Significantly[a] stunted	(14.8)	(17.7)	(11.5)
Mildly[b] stunted	128 (32.1)	(33.0)	(31.1)
Not stunted	212 (53.1)	103 (49.3)	109 (57.4)
Weight-for-height			
Significantly[a] wasted	(5.3)	(4.3)	(6.3)
Mildly[b] wasted	121 (30.3)	71 (34.0)	(26.3)
Not[c] wasted	257 (64.4)	129 (61.7)	128 (67.4)

[a] Significantly is defined as $X < -2$ standard deviation of NCHS median;
[b] Mildly is defined as $-2 \le X < -1$ standard deviation of NCHS median;
[c] Not is defined as $X \ge -1$ standard deviation of NCHS median.

in the NCHS reference population (15.9% below – 1SD and 2.3% below – 2SD). The findings indicate that malnutrition according to the three nutritional indicators is still prevalent among older children, although a majority of them were mildly malnourished. However, the finding on higher prevalence of malnutrition among these children was not surprising as these children were enrolled in schools located in low income areas of Kuala Lumpur. The study also found that 6.5% of the children were overweight. This prevalence was found to be similar to the prevalence of overweight (5.8%) among a larger sample (n = 8005) of urban primary school children from low-income households in Kuala Lumpur.[29] As the majority of the children in the present study were from low-income households, the finding on the prevalence of overweight indicates that overweight may no longer be associated with affluence.

To determine the relationship between family, child and school factors and child nutritional status, t-test and analysis of variance (Table 3) were conducted. The results indicate that while there were significant differences in height-for-age Z scores (HAZ) by gender (t = – 2.53, P < 0.05) and household income (t = – 2.08, P < 0.05), none of the factors investigated differ significantly for weight-for-height (WHZ). The findings indicate that male children had significantly lower mean HAZ than female children. Also, children from higher income groups had higher mean HAZ. Thus, female children and those from higher income households had better growth status than male children and children from lower income groups, respectively.

A plausible explanation for the different findings for HAZ and WHZ by income groups and gender is that HAZ is an indicator for long-term nutritional status and is frequently associated with poor overall socioeconomic conditions and/or repeated exposure to adverse conditions. WHZ, however, reflects current nutritional status of the individuals that may be influenced by many factors (for example, eating disorder, illness, diarrhea) besides the socioeconomic status of the households. Perhaps, there are other factors that contribute to the different growth status of male and female children that were not investigated in this study (for example, physical activity, birthweight, health conditions). These factors may be closely related to the long-term socioeconomic conditions of the households and thus show their effects in the prevalence of stunting rather than wasting.

Table 3. Mean Z-scores of weight-for-age (WAZ), height-for-age (HAZ) and weight-for-height (WHT) by family, child and school factors (n = 399)

Factor	WAZ	HAZ	WHZ
Family			
Household income (RM)			
1–800	– 0.912	– 1.217	– 0.398
> 800	– 0.769	– 0.778	– 0.396
	(t = – 1.090)	(t = – 2.079 *)	(t = – 0.012)
Income per capita (RM)			
1–150	– 0.867	– 0.937	– 0.382
151–300	– 0.816	– 0.875	– 0.360
> 300	– 0.842	– 0.731	– 0.555
	(F = 0.620)	(F = 0.912)	(F = 0.386)
Household size			
1–4	– 0.769	– 0.949	– 0.234
5–7	– 0.808	– 0.861	– 0.378
> 7	– 1.050	– 0.942	– 0.604
	(F = 1.204)	(F = 0.337)	(F = 1.413)
Number of children			
1–3	– 0.778	– 0.855	– 0.340
4–5	– 0. 814	– 0.906	– 0.343
> 5	– 1.065	– 0.943	– 0.625
	(F = 1.374)	(F = 0.231)	(F = 1.334)
Child			
Male	– 1.005	– 1.051	– 0.474
Female	– 0.677	– 0.773	– 0.312
	(t = – 2.531*)	(t = – 2.322 *)	(t = – 1.171)
Birth order			
1–2	– 0.806	– 0.891	– 0.352
3–4	– 0.807	– 0.840	– 0.392
> 4	– 1.030	– 0. 998	– 0.513
	(F = 0.897)	(F = 0.624)	(F = 0.360)
School			
1	– 0. 890	– 1.103	– 0.357
2	– 1.001	– 1.009	– 0.519
3	– 0. 916	– 0.917	– 0.331
4	– 1.011	– 1.015	– 0.496
	(F = 0.781)	(F = 0.471)	(F = 0.539)

* P < 0.05.

Educational achievement

In the sample, 37.3% of the children had optimum educational achievement total score (TS) and 31.3% had sufficient and insufficient scores. For individual subjects, while more than 70% of the children had at least sufficient scores for ML and MT, only 50% of the children had sufficient scores for EL. Thus, insufficient educational achievement was higher in EL (50.9%) compared to ML (26.3%) and MT (26.1%). Also, compared to the mean scores for ML and MT, the children had lower mean scores for EL (51.6 ± 26.5). Table 4 presents the educational test scores for the individual subjects and overall result.

Pearson correlation analysis (Table 5) was performed for the individual subjects (ML, EL, MT) and TS. The correlations among the subject exceeded 0.7 and were significant (P < 0.01). Similarly, each subject correlated significantly (P < 0.01) with the TS. These findings implied that children who had high scores in a subject were more likely to have high scores for other subjects and better overall educational achievement (TS).

Analysis of variance was conducted to examine the differences in educational achievement TS in relation to family, child and school factors (Table 6). School children from households with higher incomes (t = – 3.82, P < 0.001) had significantly better TS. Also, children from households above the poverty line (≤RM150) had significantly higher TS than

Table 4. Educational achievement test scores (n = 399)

Subject	Range	Mean score (SD)[a]	Percent with test score ≥ 50 or ≥ 150
Malay language (ML)	2–100	69.9 (27.7)	73.7
English language (EL)	0–100	51.6 (26.5)	49.1
Mathematics (MT)	0–100	65.7 (26.1)	73.9
Total Score (TS) [b]	12–299	187.2 (71.2)	68.7

[a] Standard Deviation, [b] Total Score = ML + EL + MT.

those living in poverty (<RM150) ($F = 10.87$, $P < 0.001$). In separate analyses for male and female children (data not shown), while female children from households with lower income had a poorer overall result ($t = 3.49$, $P < 0.01$), this was not observed among the male children. However, both male ($F = 6.26$, $P < 0.01$) and female children ($F = 5.57$, $P < 0.01$) from households with income per capita of ≤RM150 had lower TS than children from the other two groups, with significant difference observed only between children in <RM150 and RM300 groups. Nevertheless, the trend remains that children from households with higher income per capita had better overall test scores than those from lower income per capita households.

Table 5. Correlations among educational achievement test scores ($n = 399$)

Subject	ML	EL	MT	Total Score (TS)[a]
Malay language (ML)	–	0.72	0.77	0.92
English language (EL)	–	–	0.78	0.85
Mathematics (MT)	–	–	–	0.88

[a] Total Score = ML + EL + MT All correlations are significant at $P < 0.01$.

Table 6. Mean of educational achievement total score (TS) by family, child and school factors ($n = 399$)

Factor	Total Score Mean (± SD)	*T* or *F*-value
Family		
Household income (RM)[a]		
1–800	175.3 (72.3)	– 3.820***
> 800	202.2 (67.2)	
Income per capita (RM)[a]		
1–150	175.9 (70.8)	10.872***
151–300	193.2 (72.3)	
> 300	225.0 (55.3)	
Child		
Male	174.4 (66.5)	– 3.832***
Female	201.3 (67.1)	
Birth order		
1–2	201.0 (66.5)	7.846***
3–4	181.9 (74.6)	
> 4	164.4 (69.4)	
Underweight		
Significant underweight	172.2 (69.5)	2.159
Mildly stunted	185.8 (72.6)	
Not stunted	193.2 (70.4)	
Stunting		
Significant stunted	162.4 (72.2)	5.565 **
Mildly stunted	183.8 (68.8)	
Not stunted	196.2 (70.9)	
Wasted		
Significant wasted	183.7 (71.2)	1.037
Mildly wasted	(75.7)	
Not wasted	200.9 (51.9)	
School		
1	184.3 (77.4)	0.421
2	185.2 (65.7)	
3	187.0 (80.0)	
4	187.2 (71.2)	

[a] RM1 = USD3.8, ** $P < 0.01$, *** $P < 0.001$.

Similar to nutritional status, male children had significantly lower TS than female children ($t = -3.83$, $P < 0.001$). However, in terms of the three nutritional indicators, TS only differed significantly according to height-for-age ($F = 5.57$, $P < 0.01$). The difference was only significant between children who were significantly and those who were not stunted, although there was a progressive decline in TS from the 'not stunted' to 'significantly stunted' categories. Separate analyses were conducted for male and female children to examine the difference in TS by height-for-age (data not shown). The results indicated only among female children that TS differed significantly between those were stunted (mildly stunted – 186.68; significantly stunted – 186.51) and not stunted (212.30) ($F = 3.51$, $P < 0.05$). For male children, no significant difference was observed among the three groups, although male children who were not stunted had higher mean score (188.41) than those who were mildly (176.25) and significantly (151.92) stunted.

In terms of birth order, children of lower birth order (2 or less) had significantly higher TS than children from the other two groups ($F = 7.85$, $P < 0.001$). The difference in TS by birth order was significant for male ($F = 3.62$, $P < 0.05$) and female children ($F = 3.55$, $P < 0.05$) with those of lower birth order (2 or less) having higher TS than TS children in other groups (data not shown). However, for these male and female children, significant difference was observed only between those in the lowest (1–2) and highest (>4) birth order groups.

Besides nutritional and health status, other factors such as household socioeconomic status and school facilities/teaching (for example, availability of teaching materials, text books and teacher's motivation) have also been shown to influence children's school outcomes. Since educational achievement differed significantly by household socioeconomic status (household income and income per capita) and not by schools (Table 6), only household socioeconomic status was considered for analysis of covariance. This analysis is to examine whether the relationship between educational achievement and nutritional status is confounded by socioeconomic status (Table 7). The results indicate that the

Table 7. Analysis of covariance (ANCOVA) of educational achievement total score (TS) by nutritional status (stunting) after controlling for households' socioeconomic status ($n = 399$)

Factor	Total Score Mean (± SD)	*F*-value
Household income		
Nutritional status		
Significant stunted	166.3 (68.7)	4.264*[a]
Mildly stunted	183.9 (68.4)	
Not stunted	195.1 (68.6)	
Income per capita		
Nutritional status		
Significant stunted	165.3 (68.5)	4.713**[b]
Mildly stunted	183.7 (68.3)	
Not stunted	195.5 (68.4)	

* $P < 0.05$, ** $P < 0.01$, [a] Total $r^2 = 0.084$, [b] Total $r^2 = 0.085$. Household Income and Income per Capita headings indicate that the analyses have controlled these two variables before producing the results for the nutritional status.

effect of poor nutritional status on educational achievement still persists even after household income ($r^2 = 0.084$, $F = 4.26$, $P < 0.05$) or income per capita ($r^2 = 0.085$, $F = 4.71$, $P < 0.01$) were controlled. Regardless of socioeconomic status (SES), there is a progressive decline in TS as children go from being significantly stunted to not stunted.

A stepwise multiple regression was performed to determine the combination of factors that best predict children's educational achievement (TS). Educational achievement was found to be significantly related to household income, birth order, gender and height-for-age ($r^2 = 0.161$, $F = 18.84$, $P < 0.001$). Table 8 presents the individual contribution of the significant factors to the educational achievement variance. Household income ($r^2 = 0.064$) contributes the most to the regression variance, followed by birth order ($r^2 = 0.042$), gender ($r^2 = 0.035$) and height-for-age ($r^2 = 0.02$). These results confirmed those previously shown (Table 6) that educational achievement differs significantly according to household socioeconomic status, gender, birth order and height-for-age. Better educational achievement was associated with higher household income, lower birth order and better nutritional status. Also, female children were more likely to have better TS than male children, maybe due to their better nutritional status.

In separate multiple regression analyses for male and female children, different significant predictors for educational achievement were obtained. For male children (Table 9), only household income ($r^2 = 0.071$) and birth order ($r^2 = 0.047$) had significant effects on TS ($r^2 = 0.118$, $F = 13.76$, $P < 0.001$). Among the female children (Table 10), birth order ($r^2 = 0.073$), household income ($r^2 = 0.042$), and height-for-age ($r^2 = 0.02$) were significant predictors of TS ($r^2 = 0.135$, $F = 9.61$, $P < 0.001$). In both groups of children, higher household income and lower birth order were associated with better TS, but only among female children did poor nutritional status have a negative effect on educational achievement. The finding that stunting was a significant contributor to low academic achievement for female children (and not for male children) was consistent with the finding (data not shown) that TS only differed significantly between stunted and not stunted female children ($F = 3.51$, $P < 0.05$) (and not between stunted and not stunted male children, $F = 1.05$, $P = 0.12$)

Table 8. Combination of factors that best predict educational achievement – total score (TS) ($n = 399$)

Factor	% Contribution to the explained variance	Beta	*P*-value
Household income	6.4	0.22	0.000***
Birth order	4.2	–0.21	0.000***
Sex	3.5	0.18	0.000***
Height-for-age	2.0	0.12	0.009**
Total r^2	16.1		

** $P < 0.01$ *** $P < 0.001$.

Table 9. Combination of factors that best predict educational achievement – total score (TS) for male children ($n = 209$)

Factor	% Contribution to the explained variance	β	*P*-value
Household income	7.1	0.26	0.000***
Birth order	4.7	–0.22	0.001**
Total r^2	11.8		

** $P < 0.01$, *** $P < 0.001$.

Discussion

Our data on height and weights (Table 2) of schoolchildren in Kuala Lumpur indicate that malnutrition is still prevalent among the underprivileged communities in Malaysia. In this sample, the prevalence of mild-significant stunting (47%) was higher compared to that of mild-significant wasting (36%). As stunting reflects past nutrition, the finding indicates that these children may have had experiences with poor diets and infections during their early childhood and perhaps were continuously living with similar conditions as a consequence of poverty. However, the question remains whether these stunted children can regain their heights (catch-up growth) in later childhood. Martorell *et al.*[30] reported that catch-up growth can occur with improvements in living conditions more effectively in very young children than older children. However, if the children remain in similar impoverished conditions, there is a little or no chance that catch-up growth will occur. Thus, stunting in school children and adolescents may be less reversible and consequently can lead to short adult stature.

In comparing the growth status of the Malay children in this sample with other growth assessment studies in Malaysia, the findings were quite similar. Chee's[31] study of growth status among children aged 5–10 from a squatter settlement in Selangor, found that 19.8% were significantly stunted and 33.6% were mildly stunted. The prevalence of significantly and mildly wasted was 9.3% and 32.7%, respectively. Another study reported that the overall prevalence of stunting and wasting (< – 2 SD of NCHS reference median) among Malay children were 15% and 3%.[32] In a much earlier study by Chen, 25% and 9% of school children (aged 6–9.9) from schools in Kuala Lumpur and Selangor were stunted and wasted.[33] However, for the Malay children, the prevalence for stunting and wasting was 38% and 7% (stunting was <90% of height-for-age and wasting was <80% of weight-for-height). The finding that the prevalence of stunting is higher than wasting in this sample of Malaysian school children agrees with findings from other less developed countries which indicate that shortness-for-age is a common

Table 10. Combination of factors that best predict educational achievement – total score (TS) for female children ($n = 190$)

Factor	% Contribution to the explained variance	β	*P*-value
Birth order	7.3	– 0.27	0.001 **
Household income	4.2	0.21	0.003 **
Height-for-age	2.0	0.14	0.042 *
Total r^2	13.5		

* $P < 0.05$, ** $P < 0.01$.

nutritional insult among low-income school children compared to wasting.[34–38]

The *t*-test analyses indicated that male children had lower mean HAZ than female children (Table 3). These findings were supported by the fact that more male than female children were underweight, stunted and wasted. Gender differential in the study of child nutritional status in the less developed countries has frequently reported that male children were favoured in that they were breast-fed longer, received better quality diet, child care time, health treatment and had better nutritional status.[39–44] However, many of these studies focused on preschoolers rather than school-aged children. The present findings indicate that more male children were at risk of poor growth than female children. This was similar to the longitudinal findings of school children in Zanzibar in that boys are more vulnerable to stunting than girls.[38] However, other studies of Nigerian and Vietnamese school children have shown that female children had poorer health or growth status than male children.[45,46]

Several explanations have been postulated for the difference in growth status between male and female children in this study. According to Martorell *et al.*,[30] prolongation of the growth period can make up for some of the earlier growth retardation. In other words, if the maturation process is grossly delayed and the growth period is extended, than the potential for catch-up growth will be marked. However, as shown by Satyanaryana *et al.*,[47,48] the effects of maturation delay may differ in male and female children in that growth retardation in early childhood was slightly increased by adulthood in males, but decreased in females. Martorell *et al.*[30] also indicated that children may not achieve the potential for catch-up growth if they continue to live in the same environment which gave rise to stunting in early childhood. As this is a cross-sectional study, information on the duration of time that the children have been living in socioeconomically deprived situations is not available. However, the comparison of household SES between male and female children in this sample indicated that there is no significant difference in household income and income per capita between the two groups (data is not shown). Perhaps, other factors such as birthweight, physical activity, food intake and health conditions which were not investigated in this study might contribute to the difference in growth status between male and female children. For example, the effect of low birthweight on the prevalence of short stature studies have shown that children with low birthweight were shorter, thinner and had less weight gain than the optimal birthweight children.[49–51] The effect of low birthweight on the prevalence of short stature may not only remain significant during the early childhood or in the first decade of life but it may also extend into adolescence and adulthood.[52–55]

It has been reported that as long as height-for-age is stable after the minimum age of school enrolment (6-year-old) then there is little or no catch-up growth and height-for-age at 8 or 9 years old reflects the effect of early childhood nutrition on school outcomes.[56] In the present study, among the three nutritional status indicators, educational achievement differed significantly only according to height-for-age. This indicates that the process of stunting which corresponds to prolonged nutritional deficiencies, may have a persistent effect on cognitive development which consequently affects the children's learning capabilities in schools. Gardner and Grantham-McGregor stated that the mechanisms which link undernutrition and poor development in children are not well understood, although children who were moderately to severely malnourished during their early childhood show delayed development.[57] Several hypothetical mechanisms have been suggested, such as that undernutrition causes irreversible changes of the central nervous system which affect function; poor social background of malnourished children may independently or interact with undernutrition to delay development; and inadequate caloric intake may negatively affect child's inquisitiveness through poor locomotor development and reduced activity levels. In fact, the developmental impairments, particularly that of cognitive development, due to undernutrition may extend well beyond childhood to produce less productivity in adults.

Other studies have also shown the association between height-for-age as a measure of nutritional status and school performances or ability outcomes.[8–11,14] A study of over 3000 children in China found that children with lower height-for-age were consistently further behind in their expected school grade.[8] The author further concluded that because of the inconsistent effect of weight-for-height on grade attainment, height was a better predictor than weight. Similarly, Moock and Leslie reported that nutritional status as measured by height-for-age was a significant determinant of both school enrolment and grade attainment among primary schoolchildren in the Terai region of Nepal.[9] Besides the relationship between height-for-age and grade attainment or school enrolment, height-for-age is also significantly related to other measures of cognitive development such as IQ, test score achievement and school attendance.[10,14] In this present study, the absence of significant relationship between weight-for-height and educational achievement indicate that recent poor nutritional experiences may not significantly contribute to children's cognitive development. In fact, based on the review of several studies, weight-for-height was less consistently associated with school outcomes.[58]

This study had no prior knowledge on which schools were more successful in educational achievement. School factors (teaching facilities, teachers, motivation, teaching curriculum) may certainly contribute to the children's school performance. However, in this study we did not find any significant difference in educational achievement among children in the four schools. The fact that male children had significantly lower educational achievement than female children may actually relate to the overall poorer nutritional status of male children (height-for-age and weight-for-age). Again, being malnourished or having to live in similar deprived environment for a long time may have a negative consequence on the overall development of a child. We also found that educational achievement differed significantly according to birth order, in which children of higher birth order (≥3) had significantly lower test scores. Several explanations for this are: (i) as seen in many less developed countries, children of higher birth order are more at risk of poor health, especially if the birth interval between two pregnancies is short; (ii) perhaps in this study, higher birth order children may lack mental stimulation or attention from the parents due to the presence of many siblings or the parents are working.

Continuous undernutrition along with poverty may further permanently retard a child's development. This is because poor diet quality is frequently correlated with other qualities of life such as socioeconomic status, health and child care. In this present study, we found that children from households with a monthly income of RM800 or less had significantly lower overall TS. Similarly, children from households with a lower income per capita would score less than those from higher income per capita groups (Table 4). According to Schiefelbein and Simmons and a report by Reid, socioeconomic conditions and parental attitudes may contribute to children's educational attainment.[59,60] Poor socioeconomic status of the households and lack of interest in education among the parents have been documented to negatively affect children's academic performance. In the present study, the four schools have been categorized by the Malaysian Ministry of Education as schools with low-income parents or guardians. Many of the children who attended the schools came from squatter areas, long houses (transitional residence from squatters to low-income houses or flats) and low-income flats. The effects of socioeconomic conditions in this sample of children may be seen in the children's dietary intakes, birthweight and general health, however, these factors were not investigated in the present study. In addition, based on information from the principals and teachers in these schools, many of the parents were less interested and cooperative in their children's education. For example, free tutorial sessions offered by the teachers for the students were not well received by the students and parents. Perhaps, other factors (for example, both parents are working, large household size) related to poor socioeconomic status may contribute to lack of parental interest or attention in their children's education.

As low SES may have negative consequences on both nutritional status and educational achievement, as we proceeded to show that the overall effect of poor nutritional status (low height-for-age) on educational achievement of the school children is independent of SES (Table 7). Regardless of SES, school children who were mildly and significantly stunted had lower overall TS than the non-stunted children. In a study of Guatemalan school children, health and nutrition variables (height-for-age, hemoglobin, clinic attendance, blood lead levels, ferritin levels, upper respiratory infection, fever and breakfast rating) contributed significantly to school achievement, even after socioeconomic variables were controlled.[14] Johnston *et al.* reported that children from among a disadvantaged community in Guatemala, stature and SES interact with each other to predict IQ.[10] In the upper three SES quartiles, children's IQ increased with stature, but among the most disadvantaged children (first SES quartile), no relationship between stature and IQ was observed. The authors concluded that among the most disadvantaged children, SES may take precedence over stature as a predictor of cognitive development.

In the present study, household income as a measure of SES was the most significant predictor of educational achievement (Table 8) followed by child factor (birth order, gender and height-for-age). Although height-for-age contributes the least to the variance in the regression model, it is consistent with other findings that low height-for-age as an indicator of early childhood malnutrition may have a negative consequence on cognitive development.[8–10,14] For example, Clarke *et al.* reported that height-for-age was the most significant predictor (among other health and nutrition variables) of school achievement. In the present study, the combination of four factors (household income, birth order, gender and height-for-age) to predict educational achievement may reflect the interactive effects of socioeconomic, health and biological factors.[14]

The low contribution (16%) of the most significant factors to explain the educational variance among these Malaysian schoolchildren may suggest that other factors that are not measured in this study, such as educational system, family and child backgrounds, characteristics and interactions, child's health, nutritional status, IQ and dietary intake, socioculture and socioeconomic status could be more prominent as predictors of educational achievement. For example, Sigman and Neumann found that cognitive scores were best predicted by a combination of factors which include duration of schooling, intake of animal protein, weight-for-age and SES.[11] All of these factors accounted for 54% of the cognitive variance. In a sample of Chilean schoolchildren, intellectual ability, type of school, SES and age were the most significant parameters explaining 45% of educational achievement variance.[13] Others have shown that various measures of health, nutrition, child's background and characteristics, school factors and SES should be included in order to have a holistic view of contributory factors to school outcomes.[6,10,14,61] Indeed, any school outcome is not a consequence of a specific factor, but rather of the interaction of various factors within the child's ecology. Similarly, these various factors will not only affect the cognitive development of the child but also other aspects of child development such as physical, psychological and social.

Although this study highlights only several factors which contribute to a child's educational achievement, it is already established from various studies in other less developed countries that health and nutrition do play a significant role in a child's cognitive development. The research findings from this study strongly suggest that efforts to improve a nutritional status may indeed have educational as well as health benefits. At present, there are various health and nutrition programs targeting at-risk schoolchildren in Malaysia, but efforts to identify these children and to monitor their health and nutritional status need to be intensified. Also, as stunting (low height-for-age) is more common among the school children than wasting or underweight, this should signal the health authorities that early childhood malnutrition will not only manifest itself in children's future health and nutritional status, but also their overall development. The process of stunting may be associated with concurrent risks to the health and development of schoolchildren. In the long term, stunting may result in shorter adult height, which decreases work capacity and increases reproductive risks for women.[62]

If the goal of the government is to improve the nation's educational attainment, then it is imperative to focus on all factors associated with educational achievement including health and nutrition. As the Malaysian schoolchildren are diagnosed with a wide range of health and nutrition problems, such as malnutrition, dental caries, lice, skin diseases, helminthic infections, vitamin deficiencies, overweight and anemia,[63] we should determine which health and nutrition problems do contribute to their school outcomes. In fact, some of the health and nutritional problems experienced by these Malaysian children are similar to the health conditions reported to be common among schoolchildren in other less developed countries and which have potential impact on a child's educational attainment.[3]

It is recommended that School Health Service in Malaysia should also monitor the health and growth of primary schoolchildren. Weight and height measurements are easy and inexpensive to perform and can be used as indicators of poor health and nutritional status. For example, in Central America and Panama, height censuses of all children who attend first grade primary school have been used effectively to detect growth retardation, to screen high-risk groups and to target social interventions. This methodology is not only simple and inexpensive, but has also been confirmed as reliable and valid by the Institute of Nutrition of Central America and Panama (INCAP).[64] At present, weight and height measurements of the school children are taken at least once a year, however, their use remains questionable. The measurements are available in the school records without being used by the school or health officials. Perhaps, it is time to look into this alternative of having a growth or health database that may enable us to regularly monitor the health and nutritional status of the Malaysian schoolchildren.

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