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Background

Early childhood development has far reaching consequences on an individual's cognitive performance, which in turn affects his or her lifelong productivity, socioeconomic status (SES) and health. Cognitive performance involves the adaptive mental processes of perception, reasoning, creativity, problem solving and intuition that are measured by intelligence quotient (IQ) [1]. Poor cognitive development and low IQ levels among children may eventually lead to problems in mental health [2], social development, peer relationships as well as physical health [3], all of which can subsequently affect their quality of life when they are adults [4].

Poor cognitive performance in children has been linked with multiple risk factors related to low SES, such as parental education level and in particular low maternal schooling [5, 6], malnutrition, micronutrient deficiencies [7], non-stimulating environment [8], childhood infections [9, 10] and hearing impairment [11].

SES is a multidimensional construct typically characterized by education, income and occupation [12]. Results from developed and developing countries consistently supported the links among SES, nutritional status and cognitive performance [13–23]. Nutritional status, an associated factor of SES [13, 14], also plays a crucial rule in predicting cognitive performance. Good nutrition provides the building blocks for brain and neural system development [15]. Studies have regularly linked cognitive performance with both over- and under-nutrition. Sandjaja et al. [16] reported that both under- and over-nutrition can contribute to poor cognitive performance among Southeast Asian children aged 7–12 years. Another study has associated increased body mass index (BMI) with poor cognitive performance among children and adolescents aged 8 to 16 years in the United States [17]. An Indonesian study found that

Cognitive performance

Trained research assistants administered age-appropriate, validated psychometric Raven's Progressive Matrices (RPM) to assess the non-verbal intelligence quotient (IQ) of the children. Care was taken to administer the RPM to the children individually in a comfortable room that was well lit and free from noise. For children aged 5 to 11 years, Coloured Progressive Matrices (CPM; Raven) [28] were used and Standard Progressive Matrices (SPM; Raven) [29] were administered to children aged 12 years. The CPM consist of three sets of 12 problems, while the SPM consist of five sets of problems, with each set becoming progressively more difficult. Each correct answer was given a score of 1, making a total raw score of 36 for CPM and 60 for SPM. The total raw scores were then converted into a standard score based on norm tables, and subsequently categorized into the relevant non-verbal IQ categories: ≥120 (superior); 110–119 (high average); 90–109 (average), 80–89 (below average); < 80 (low/borderline) [28, 29].

Anthropometric status

Anthropometric measurements, including body weight and height were measured by trained research assistants. The measurements were taken with the children wearing light clothing and not wearing shoes. Height was measured to the nearest 0.1 cm, with a portable SECA stadiometer Model 213 (SECA, Hamburg, Germany). Body weight was taken to the nearest 0.1 kg using a SECA digital weighing scale Model 803 (SECA, Hamburg, Germany). Measurements were taken twice and the mean was calculated. Body mass index (BMI) was calculated by dividing the measured weight (kg) by the square of height (m^2).

Anthropometric status was classified according to the age- and sex-specific WHO [30] growth reference using the WHO AnthroPlus 1.0.3 (World Health Organisation, Geneva, Switzerland). The cut off values for thinness was BAZ < -2SD, while overweight and obesity were > 1SD and > 2SD, respectively. Severe obesity was defined as BAZ > 3SD. The cut off value for stunting was HAZ < -2SD [30].

Data anal sis

Data was analyzed using complex samples technique in SPSS version 20.0 (IBM Corporation, New York, USA), using a sampling weight factor developed based on the Malaysian population census 2010 [31]. Descriptive statistics, including mean, standard error (SE), percentage and 95% confidence interval (CI), were used to describe sociodemographic characteristics, nutritional status and cognitive levels. Likelihood-ratio tests were used to test the association of socioeconomic and nutritional status with IQ categories. The difference in IQ distribution of children by SES and nutritional status was described by percentages and 95% confidence interval (CI) estimates.

Independent variables which produce likelihood ratio with p-value of 0.2 and below in univariate analyses, or change the odds ratio of the variable of interest by 10% or more, were included in the multivariate logistic regression model. Complex samples logistic regression analyses were performed to determine the odds ratio (OR) after adjusting for putative confounding variables. The OR represents the probability of getting lower IQ relative to those with high average/superior IQ (reference group).

Two regression models were presented. Model 1 was unadjusted with household income, paternal and maternal education, BAZ categories as the primary independent variables. Model 2 was further adjusted by sex, age, ethnicity and residence as these factors had been previously reported to influence children's cognition [7, 32]. The logistic regression models were also checked for the moderating effect of sex and age group on association with IQ levels. Due to insignificant interaction terms ($p > 0.05$), the regression models were presented without stratification. The significance level was set as $p < 0.05$ using two-sided tests for all analysis.

Results

Table 1 illustrates the sample characteristics according to SES, anthropometric status and non-verbal IQ. Mean age of the children was 9.0 ± 0.1 years. Nearly 59.1% were Malays, followed by Chinese (19.2%), Other ethnicities (15.0%) and Indians (6.7%). A third of the children were from very low income households (< MYR1500 per month) and less than one fifth belonged to high income households (≥ MYR5600 per month). About two-thirds of the children had parents who had completed secondary school education (fathers: 64.6%; mothers: 66.4%). The proportion of children who were stunted, thin and severely obese were 6.0%, 6.9% and 4.9%, respectively.

Four out of ten children (39.1%) had average non-verbal IQ. A third of the children (35.0%) had above average (high average and superior) non-verbal IQ, while an eighth (12.2%) were categorized as having low or borderline IQ (Table 1). The distribution of the children's non-verbal IQ categories by sociodemographic characteristics and nutritional status is shown in Table 2. A larger proportion of children from families with very low household income had low/borderline IQ (17.3%), while high income households had a larger proportion of children with superior IQ (29.4%). The same is true for parental education level, where a higher proportion of children whose parents had the lowest education level were categorized as having low/borderline non-verbal IQ (paternal: 17.7%; maternal: 21.8%), and, in contrast, a higher proportion of children whose parents had tertiary

Table 1 Sociodemographic characteristics, nutritional status and intelligence quotient (IQ) of children aged 5.0 to 12.9 years education were categorized as having superior non-verbal IQ (paternal: 25.4%; maternal: 26.2%). In terms of ethnic groups, Chinese children had the lowest proportion of low/borderline non-verbal IQ (7.5%) and the highest proportion of superior non-verbal IQ (28.5%). There was no significant association of BAZ and HAZ with IQ categories.

Table 3 shows that the OR of logistic regression models improved after adjusting for covariates. Children from households with very low income had twice the odds of having poor non-verbal IQ [low/borderline/below average, OR = 2.01, (95%CI 1.16, 3.49)], when compared with children from high-income families. The odds of having poor IQ level also doubled among children whose parents did not attend school or who

Table 2 Distribution (%) of children's intelligence quotient (IQ) by sociodemographic characteristics and nutritional status categories

	Low/borderline		Below average		Average		High average		Superior		Likelihood ratio	p value
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI		
Sex												
Boys	10.1	8.3, 12.2	14.3	11.6, 17.5	38.0	34.5, 41.7	20.7	17.9, 23.7	16.9	14.5, 19.7	18.726	p < 0.05
Girls	14.5	11.9, 17.6	13.1	10.6, 16.0	40.3	36.6, 44.1	15.9	13.5, 18.6	16.3	13.6, 19.3		
Age groups												
5.0–6.9 years	14.6	11.3, 18.7	11.9	9.2, 15.4	36.0	31.5, 40.7	19.4	15.9, 23.4	18.1	14.8, 22.0	37.301	p < 0.01
7.0–9.9 years	12.4	10.1, 15.1	13.5	11.0, 16.5	36.2	32.3, 40.3	17.6	14.8, 20.9	20.2	17.1, 23.8		
10.0–12.9 years	10.5	7.9, 13.8	15.0	11.4, 19.4	44.1	39.4, 48.9	18.4	15.3, 22.0	12.0	9.4, 15.2		
Residence												
Urban	11.9	10.0, 14.1	13.1	10.9, 15.6	38.8	35.8, 42.0	17.9	15.8, 20.3	18.2	16.0, 20.6	21.290	p < 0.01
Rural	13.3	11.0, 16.1	16.2	12.9, 20.1	40.3	36.0, 44.7	20.0	16.5, 24.1	10.2	8.2, 12.7		
Income groups												
Below MYR1500	17.3	14.0, 21.1	17.5	13.6, 22.2	43.2	38.4, 48.1	13.9	11.2, 17.1	8.2	6.2, 10.7	151.781	p < 0.001
MYR1500-MYR2299	12.9	9.3, 17.7	13.9	10.3, 18.5	37.9	32.0, 44.2	21.5	17.0, 26.9	13.8	10.4, 18.1		
MYR2300-MYR5599	9.9	7.5, 13.0	10.9	8.4, 14.1	40.9	36.5, 45.5	18.7	15.6, 22.3	19.6	16.3, 23.3		
MYR5600 and above	6.5	4.2, 10.1	11.8	7.9, 17.3	30.2	25.0, 35.9	22.1	17.3, 27.6	29.4	23.9, 35.7		
Paternal education level												
Non-schooling and primary school	17.7	11.9, 25.6	22.4	13.3, 35.3	36.4	27.2, 46.7	14.4	9.2, 21.7	9.1	5.4, 15.0	99.370	p < 0.001
Secondary school	14.2	12.0, 16.7	13.6	11.5, 16.0	41.0	37.7, 44.3	17.4	15.2, 19.9	13.8	11.8, 16.0		
Tertiary school	6.0	4.0, 8.7	11.3	8.2, 15.4	35.6	31.1, 40.4	21.7	18.0, 25.9	25.4	21.2, 30.1		
Maternal education level												
Non-schooling and primary school	21.8	14.4, 31.6	21.0	12.3, 33.4	37.9	27.7, 49.1	10.1	6.0, 16.5	9.3	4.9. 17.1	119.384	p < 0.001
Secondary school	13.5	11.5, 15.9	13.7	11.5, 16.2	42.2	39.0, 45.5	17.1	14.9, 19.5	13.5	11.6, 15.7		
Tertiary school	6.4	4.5, 9.0	11.9	8.7, 15.9	31.7	27.3, 36.5	23.8	19.9, 28.2	26.2	22.0, 30.9		
Ethnicity												
Malay	13.5	11.2, 16.2	16.1	13.3, 19.3	41.7	38.0, 45.5	15.5	13.0, 18.3	13.2	10.9, 16.0	117.651	p < 0.001
Chinese	7.5	5.4, 10.2	8.2	6.0, 11.1	30.5	26.3, 35.1	25.3	21.3, 29.8	28.5	24.2, 33.2		
Indian	17.6	12.1, 24.9	12.0	7.4, 19.0	45.2	35.5, 55.3	13.0	8.3, 19.7	12.1	6.8, 20.8		
Others	10.9	7.3, 16.0	12.0	8.5, 16.6	37.3	32.2, 42.7	23.2	19.2, 27.7	16.6	13.1, 20.8		
BAZ groups												
Thinness	5.9	3.3, 10.3	18.1	11.7,	44.8	34.1,	16.6	11.0,	14.6	8.9, 22.8	43.447	p =

of such micronutrients as iron, iodine, zinc and vitamin B12 which have crucial roles in neuropsychological development for cognitive performance [45]. Therefore, it is important that children consume adequate but not excessive macronutrients and sufficient micronutrients, as these nutrients are essential for cognitive development [15]. Furthermore, children with severe obesity may intensify the adverse effect of adiposity [46]. Higher adipose tissues can result in higher adipokines production, including leptin [47]. Adipokine increases insulin resistance and therefore promotes hyperinsulinemia, dyslipidemia, inflammation and endothelial dysfunction [48]. Hypertriglyceridemia (one of the dyslipidemias) will result in elevated peripheral leptin levels, which prevent the entry of leptin to the brain, thus harming brain development [48, 49], and consequently lowers cognitive performance.

The finding that severe obesity is associated with low cognitive performance can also be explained by the tendency of severely obese children to have low physical activity levels [50], possibly due to more physical and social barriers to engage in physical activity, compared to their normal weight peers [51]. The lack of physical activity has been associated with poorer cognitive performance, including executive control, working memory and cognitive flexibility in children [52]. Lack of social environment support may also discourage participation in physical activity among children who are obese [53], thus leading to poorer cognitive development.

Notably, our study does not find any association

Table 3 Odds ratio for intelligence quotient (IQ) by sociodemographic characteristics and nutritional status

		Unadjusted model[a]		Adjusted model[a]	
		OR	95% CI	OR	95% CI
Income groups[b]					
Below MYR1500	Low/borderline/below average	2.51*	1.47, 4.27	2.01*	1.16, 3.49
	Average	2.27*	1.45, 3.54	1.95*	1.24, 3.06
	High average/superior	1		1	
MYR1500-MYR2299	Low/borderline/below average	1.34	0.78, 2.30	1.15	0.66, 2.01
	Average	1.30	0.82, 2.07	1.18	0.74, 1.90
	High average/superior	1		1	

such as verbal comprehension and social reasoning. Besides, this study focuses only on SES and nutritional status as determinants of cognitive function. Further investigations into contextual variables may be required to account for other psychosocial and environmental factors – access to cognitively stimulating materials, types of preschool experiences and parent-child interactions [36, 37, 42] – that affect the cognitive performance of children. Examining the cognitive functioning and behavioral patterns of children from diverse demographic groups may offer further insights into understanding the interplay between the sociodemographic, psychosocial and environmental factors that influence the cognitive performance of children.

Conclusions

Household income, parental education level and nutritional status are associated with the cognitive performance of 5-to-12 year-old Malaysian children. This study highlights that children from lower socioeconomic classes and those with severe obesity are disadvantaged and are more likely to have poor cognitive performance. The findings of this study indicate the need for further investigation of the interrelated influences between SES and health behaviours, as well as the social and environmental factors that can improve the nutritional status and cognitive health of Malaysian children.

Abbreviations

BAZ: BMI-for-age Z-score; BMI: Body Mass Index; CI: Confidence Interval; CPM: Coloured Progressive Matrices; HAZ: Height-for-age Z-score; IQ: Intelligence Quotient; OR: Odds Ratio; RPM: Raven's Progressive Matrices; SE: Standard Error; SEANUTS: South East Asian Nutrition Surveys;

11. Roberts JE, Burchinal MR, Zeisel SA. Otitis media in early childhood in relation to children'