Does Dietary Adequacy Reflect the Cognitive Performance of Children? A Study among the Homeless Children in Klang Valley, Malaysia

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ABSTRACT

Introduction: Homeless children are prone to inadequate energy and nutrient intake which may highly influence their cognitive performance. However, few studies have been done in assessing diet adequacy and cognitive performance among homeless children in Malaysia. **Materials and Methods:** This cross-sectional study aims to assess the dietary adequacy and cognitive performance of 120 homeless children age 7-12 years living in Klang Valley. The dietary adequacy of these homeless children was assessed through two days of 24 hours of dietary recall. Dietary adequacy achievement was determined by fulfilling at least 50% of Recommended Nutrients Intake (RNI). Raven's Coloured Progressive Matrices (RCPM) test was used to assess their cognitive performance. **Results:** The homeless children had an adequate intake of energy, iron, zinc, and vitamin B12. Seventy percent of homeless children had a poor cognitive performance. This study shows that there was no association between energy, iron, and vitamin B12 adequacy with cognitive performance, whereas there was a significant (p=0.028) association between zinc adequacy and children's cognitive performance. **Conclusion:** These findings provide solid evidence-based for dietary adequacy and cognitive performance of the homeless children in Klang Valley. It is clear from the findings that both dietary intake and cognitive of these children require improvement for a better quality of life in the future. This study suggests that dietary adequacy does not relatively reflect the cognitive performance of these homeless children in Malaysia.

KEYWORDS: dietary adequacy, cognitive performance, homeless children

INTRODUCTION

The number of homeless people in Klang Valley had dramatically increased from 600 in 2014 to 2000 in 2015.[1,2] Klang Valley area has the highest number of homeless people at about 35%.[3] While a variety of definitions of the term homeless have been suggested, this study will use the definition first suggested by the National Survey of Homeless Assistance Providers and Clients (NSHAPC), in which the homeless are the individuals who live in an emergency shelter, transition house, abandoned buildings, business premises, car or others vehicles, or anywhere outside, or stay permanently under "*Program Perumahan Malaysia*".[4]

Dietary adequacy compares daily intake with the nutritional requirements of certain individuals or populations.[5] Adequate intakes that fulfill the recommended nutrient requirement are important for good health, physical growth & development, and educational performance among children.[6] Childhood nutrients intake has long-lasting consequences on the children's brain growth and development that leads to better cognitive performance.[7] Cognitive can be said as the process of gaining knowledge by reasoning or thinking beyond the senses.[8] Adequate amount of protein, vitamins, and energy sources are vital for the brain to develop and function meritoriously especially during the child growth period.[9] Besides, deficiency of micronutrients such as iodine, iron, zinc, and vitamin B complex are affecting the growth and development of the brain among children.[10,11]

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The cognitive development of children is also affected by the deficiency during the brain development period; the maximum brain development is from age 7-15 years old.[12] During this critical period, children should obtain sufficient nutrition to achieve optimal cognitive performance.

Apart from that, this study needs to be further carried out because it is one of the gaps highlighted in the Nutritional Research Priorities in Malaysia, NRP (2016-2020). The dietary patterns of the homeless have become one of the highlighted gaps under the maternal, infant, and young child nutrition areas. Additionally, there is also a need under the NRP to study the impact of care feeding practices on children's cognitive development, which indicates that it is significant to determine the intake and the cognitive performance of children due to the limited local studies on this issue. Therefore, it is a need to determine levels of diet adequacy among homeless children and their relationship with their cognitive performance.

MATERIALS AND METHODS

Subject recruitment

The target population in this study was homeless children in Klang Valley. The sample size for this study was calculated using Cochran's formula below, with a 92% confidence interval and 8% precision. The probability in the formula was using the prevalence of iodine deficiency disorder among school children in Malaysia, which is 48.2%.[13] Based on the formula, 120 homeless children were required.

Framework Design

All eligible homeless people who matched the selection criteria were identified for the sampling area purposes. The eligible criteria included the homeless children population registered in an organization, with a fixed building and who did not overlap with other centers points. The respondents included homeless children aged between 7 - 12 years old living in Klang Valley, not bedridden due to illness, and had no physical and mental disabilities. Thus, 11 homeless centers points were eligible and fit the criteria for the study purpose. By using a random sampling method, eleven cards with different homeless people centres points were folded and put in a bowl, and four center points were selected. The

cluster sampling method was applied in selecting the respondents for this study. Finally, a total of 120 homeless children were obtained from these four centre points. All respondents were given a subject information sheet, and parental/caregiver consent and child assent were obtained before data collection.

Approval for this study was obtained from the Human Ethics Board of Committees of Universiti Malaysia Terengganu (UMT) before data collection with the reference number of UMT/JKEPM/2018/25. Ethics approval from the Ministry of Education through the online system Educational Research Application System Version 2.0 (eRAS 2.0), Education Department of Federal Territory of Kuala Lumpur, and Social Welfare Department (JKM) were obtained to conduct the study in the selected homeless centres points. The reference number of approval from the Ministry of Education, Education Department of Federal Territory of Kuala Lumpur, and Social Welfare Department (JKM) were KPM.600-3/2/3-eras(985), JPNWP.900-6/1/7, and JKMM100/12/5/2:2018/286, respectively.

Research Instruments

This cross-sectional study involves a researcher-administered approach by using a questionnaire that consists of three prominent parts. Part 1 obtains the socio-demographic and economic information of homeless children. All these questions were administered by the interviewer and answered by the children with the assistance of their guardians or parents.

Part 2 was the 24-hour dietary recall. Respondents were asked to recall the food that they had eaten one day ago to determine their dietary intake adequacy. In these dietary adequacy assessments, an album of food photos with household measurements for the respective foods was provided to the children, guardians, or teachers so that they would have better recognition of the household measurements and amount of food eaten by the children.[14] In this study, energy intake and a few significant micronutrients in cognitive function were selected such as iron, zinc, and Vitamin B12. Nutritionist Pro Diet Analysis based on Malaysia Food Composition Database was used to analyze the nutrient intake among homeless children. The results were compared with Recommended Nutrient Intake

(RNI) for Malaysia (2017)[15]. Thus, based on the RNI, energy intake for low active (PAL 1.4) children between aged 7 - 12 ranging between 1410 kcal per day to 1690 kcal per day was selected as a point of reference. Adequacy intake of energy and micronutrients was considered achievable if the mean of nutrient intake has met or exceed 50% of the RNI.

The cognitive performance test consists of 36 questions with diagrammatic puzzles of Ravens Coloured Progressive Matrices (RCPM). Raven's Coloured Progressive Matrices is a non- verbal test that is used to assess the cognitive performance of children from different language communities as it can measure the ability of children by using non-verbal stimuli.[16] The interviewer showed children three sets of diagrammatic puzzles. Each of the sets contained 12 matrices from easiest to hardest. In each matrix, there was a missing piece. Six choices for the missing pieces were listed below the matrices. There was only one correct answer and children were required to determine the missing pieces from the choices provided. One score was given for each of the correct answers whereas zero score was given to the wrong answer. Therefore, the range for the total raw score was between 0 and 36 points. The total raw score obtained was then transferred to a standard score using the RCPM table according to age band. Lastly, children were categorized into a different group of qualitative description according to their standard score: <70 points (Extremely low), 70-79 points (Borderline), 80 -89 points (Low average), 90-109 points (Average), 110-119 points (High average), 120-129 points (Superior) and >130 points (Very superior).

Data Analysis

A normality test was carried out before data analysis. A Chi-square test was performed in determining the association between dietary adequacy and children's cognitive performance. Fisher's Exact Test was used when more than 20% of the expected value in each cell is greater than 5 was obtained.

RESULTS AND DISCUSSION

Demographic profile
It can be seen from Table I that most of the respondents were female and aged 9 years old.

Table I: Respondents' Socio- demographic Profile (n = 120)

Variables	Frequency (Percent)	Mean ±SD / Median (IQR)
Gender		
Male	58 (48.3)	
Female	62 (51.7)	
Age		9 (2)
7	25 (20.8)	
8	26 (21.7)	
9	21 (17.5)	
10	25 (20.8)	
11	11 (19.2)	
Citizenship		
Malaysian	78 (65.0)	
Non- Malaysian	18 (15.0)	
Stateless	24 (20.0)	
Household income (MYR)		
<500	12 (10.0)	
501 – 1000	47 (39.2)	
1001 – 1500	21 (17.5)	
>1500	40 (33.3)	
Current home		
Purpose built flat	33 (27.5)	
Emergency shelter	36 (30.0)	
Abandoned building	0 (0.0)	
Dwelling with business premises	0 (0.0)	
Vehicle	0 (0.0)	
Shop house	34 (28.3)	
Others	17 (14.2)	
Duration of being homeless/ living in shelter/renting		
2 weeks	1 (0.8)	
2 months	1 (0.8)	
3 months	1 (0.8)	
6 months	1 (0.8)	
1 year	17 (14.2)	
2 years	11 (9.2)	
3 years	8 (6.7)	
4 years	11 (9.2)	
5 years	9 (7.5)	
6 years	8 (6.7)	
7 years	12 (10.0)	
8 year	10 (8.3)	
9 years	12 (10.0)	
10 years	10 (8.3)	
11 years	8 (6.7)	
Life satisfaction		
Extremely dissatisfied	1 (0.8)	
Dissatisfied	27 (22.5)	
Neutral	22 (18.3)	
Satisfied	67 (55.8)	
Extremely satisfied	3 (2.5)	
Financial support		
Yes	67 (55.8)	
No	53 (44.2)	

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Frequency of daily meal consumption		3 (1)
2 times	4 (3.3)	
3 times	63(52.5)	
4 times	48(40.0)	
5 times	5 (4.2)	
Food Source*		
Homemade	90 (25.9)	
Food stall	42 (16.3)	
School	117(45.5)	
Daycare	20 (7.8)	
Friends or relatives' house	4 (1.6)	
Restaurant	16(6.2)	
Soup kitchen (charity organization)	58(22.6)	

*respondent can answer more than one options

Dietary adequacy of homeless children

It is somewhat surprising that both age groups of 7 - 9 years old and 10 - 12-year-old had adequate intakes of total energy, as shown in Table II. All energy intakes based on age- and gender-specific had exceeded 50% of the RNI requirement (more than 66%) which indicates as fulfilling diet adequacy. Homeless children in this study had been reported to usually consume fried rice, fried noodles, white rice, fried chicken, and at least one cup of sugary beverage such as tea or rose syrup per day reflecting high intake of carbohydrate and fat sources. This study is in line with previous studies that found that street children had adequate energy intake where their meals were mostly energy-dense, rich in carbohydrate and fat, with little variety of side dishes.[17,18] A possible explanation for this could be that children in both studies had a high intake of energy-dense foods contributing to the total energy adequacy.

This finding is contrary to previous studies which have suggested that homeless children have low energy intake compared to Recommended Daily Allowance (RDA).[19] Work of previous studies reflects those of Patriasih et al. found that only 20% of street children in Bandung, Indonesia met energy requirements (i.e. 90 -110% of RDA fulfillment was only considered adequate).[20] It is encouraging to compare this figure with that found by Yang et al., who found that a majority of the primary school children in Klang Valley aged 10 to 12 years old in Malaysia fail to reach the energy requirement.[15] A possible explanation for the low percentage of daily energy fulfillment among the street children in those previous studies is may be due to the high cut-off points required to meet energy adequacy.

Another important finding was that the respondents aged 10 - 12-year-old boys and girls were unable to achieve more than 85% of the RNI for iron, as compared to the age group of 7 - 9 years that had exceed 100% of the RNI. Although they did not reach 100 percent RNI, they were considered as having an adequate intake of iron in their diet (>50% of RNI). Following the present results, previous studies have demonstrated that the homeless do achieve an adequate intake of iron. From the previous studies, iron intake of street children in several countries depicts an achievement of nearly or greater than 100% of iron fulfillment.[19,21] These findings are somewhat surprising, given the fact that other research shows low fulfillment of iron among those of low socio-economic status. A study in India reported that the percent of adequacy for the iron intake of children within the age of 7- 9 years old was only 32.2% of RDA requirements, whereas children aged 10 - 12 years old reached 44%.[22] The low fulfillment of iron intake among those children was due to poverty, poor knowledge of health and nutrition aspects among family, unequal distribution of food, and food insecurity.[22] The difference of the amount of iron consumption between the present study and previous studies may be explained by the fact that the increasing number of food assistance received from the Malaysian government and non- government organizations. This study has shown that almost all homeless children received food assistance, such as free school meals and soup kitchen foods. Another possible explanation for this is that various common foods in Malaysia contain an easily accessible source of iron for children, including canned sardines, chicken, eggs, anchovies, and so on.[15,21]

Zinc consumption needs improvement, specifically among boys aged 10 -12 years old who only managed to reach less than 50% of their zinc needs. It is difficult to explain this result, but it might be related to the higher requirement of zinc intake among 10-12-year-old male children, low intake of zinc from the diet, [23] and picky eating behaviors in their daily diet[24]. Phytates are also one of the factors contributing to zinc deficiency.[25] Phytate has a strong inhibitory effect on zinc absorption and is mainly found in staple foods like cereals, rice, corn, and legumes.[26] Perhaps consumption of higher phytate sources may cause them to have low bioavailability of zinc in their body. In contrast, animal sources food like meat, fish, poultry, and their by-products are higher in zinc contents, which can provide 80% of

total the dietary zinc.[25,27] Thus, to have an optimum intake of zinc, animal source consumption can be increased and phytate contained food should be reduced to maximize zinc absorption in the body.

Both genders for both age groups had an adequate intake of vitamin B12 with the fulfillment of 60.8 and 54% respectively but requires more improvement. Vitamin B12 obtained from children's daily diet was just based on sufficient needs for their body to carry out its functions. Higher levels of vitamin B12 are required for 10 -12-year-old children because it helps in cell division and normal growth which is essential during the puberty period.[28]

Overall, homeless children had an adequate intake of dietary nutrients, namely energy, iron, zinc, and vitamin B12.

Cognitive performance of homeless children

Most of the homeless children were in the category of borderline, which is in the second-lowest position out of the seven cognitive categories as shown in Table III. A study done on cognitive function among homeless children in Brazil found that homeless children had poorer cognitive performance compared to non-homeless children.[29]

Table II: Amount and Adequacy of Selected Nutrients Intake of Homeless Children with age group 7 to 9 years old (n=72) and 10 to 12 years old (n=48)

Components	Gender	Age Group 7-9 years (n=72)			
		RNI	Mean ± SD/ Median (IQR)	% of fulfilment[a]	Dietary Adequacy*
Energy (kcal)	Boys	1530.00	1212.24 ± 486.76	79.13	Adequate
	Girls	1410.00	1046.13 ± 332.62	74.19	Adequate
Iron (mg/day)	Boys	9.00	13.03 (9.15)	144.78	Adequate
	Girls	9.00	11.51 (6.00)	127.89	Adequate
Zinc (mg/day)	Boys	5.70	4.37 ± 2.31	76.67	Adequate
	Girls	5.60	3.37 ± 1.43	60.18	Adequate
Vitamin B12 (µg/day)	Both	2.50	1.52 (1.62)	60.80	Adequate
Components	Gender	Age Group 10-12 years (n=48)			
		RNI	Mean ± SD/ Median (IQR)	% of fulfilment[a]	Dietary Adequacy*
Energy (kcal)	Boys	1690.00	1122.29 ± 365.30	66.41	Adequate
	Girls	1500.0	1135.23 ± 399.99	75.68	Adequate
Iron (mg/day)	Boys	15.00	10.38 (8.07)	69.20	Adequate
	Girls	14.00	11.34 (5.19)	81.00	Adequate
Zinc (mg/day)	Boys	7.00	3.16 ± 1.47	45.14	Inadequate
	Girls	6.30	3.76 ± 1.98	59.68	Adequate
Vitamin B12 (µg/day)	Both	3.50	1.89 (1.51)	54.00	Adequate

[a] Percentage of fulfilment is calculated by comparing mean and recommended intake based on RNI.
* ≥ 50% of fulfilment is considered adequate whereas < 50% of fulfilment is considered inadequate (RNI for Malaysia, 2017).

Table III: Cognitive Performance of Homeless Children in Klang Valley Categorized into Seven Categories (n = 120)

Cognitive Performance Categories	Distribution n (%)	Mean ± SD
Cognitive Score		79.50 ± 14.178
Extremely Low (<70)	27 (22.50)	
Borderline (70-79)	34 (28.30)	
Low Average (80-89)	27 (22.50)	
Average (90-109)	27 (22.50)	
High Average (110-119)	4 (3.30)	
Superior (120-129)	1 (0.80)	
Very superior (≥ 130)	0 (0.00)	

Another study, showed that cognitive performance among homeless children was weaker than housed children.[30] It is encouraging to compare this finding with those of Tai and Asma who found that majority of fishermen children in Malaysia also had a poor cognitive performance.[31] It seems possible that these results are due to similar economic characteristics of respondents in both studies where they are from vulnerable groups in Malaysia. Poor cognitive performance of children can be affected by several factors such as insufficient nutrients intake, family socioeconomic status, weight status, and living environment. Homeless people can be categorized in poor and low economic status groups in which they do not have a high education level and skills. Thus, the limited income in the family has become one of the reasons that lead to poor cognitive performance among homeless children. This is because children with low economic status have a lesser opportunity in learning and have fewer chances to expose themselves in cognitive challenging task[32] causing lack of cognitive stimulation.[33]

The results as shown in Table IV reveal a significant (p<0.05) association between zinc and cognitive performance of the respondents. This is supported by a previous study which stated that low zinc intake could lead to attention deficit among children.[34] Zinc plays role in the central nervous system as a neurosecretory and cofactor. It forms zinc-containing neurons which can be found in the forebrain.[35,36] Surprisingly, there was no significant association between other selected nutrients and cognitive ability. The lack of association obtained between energy, iron, and vitamin B12 and cognitive performance can be due to other confounding factors on children's cognitive performance.

In general, the findings of this study do not support the ideas from previous studies which indicated energy, iron, zinc, and vitamin B12 had a significant relationship with cognitive performance. This finding showed that nutrient intake is not the only factor affecting the cognitive performance of homeless children. There may be other prominent factors that influence the cognitive performance of homeless children. The major limitation of this study is that the 24-hour dietary recall taken from certain homeless children may not reflect the exact dietary intake during their homeless period. No iodine dietary intake was assessed as no information of it is available in the Malaysian food composition database. It is suggested that further study on iodine adequacy and cognitive performance of homeless children can be carried out using urinary iodine tests to determine the level of iodine in the body. Despite its limitations, this study certainly contributes to our understanding of the diet adequacy and cognitive performance of these homeless children.

Table IV: Association between Dietary Adequacy and Cognitive Performance (n = 120)

Nutrients		Cognitive Performance		x^2	p-value
		Poor	Not Poor		
Energy	Adequate	74	26	0.136	0.712
	Inadequate	14	6		
Iron	Adequate	79	29	0.019	1.000
	Inade-quate	9	3		
Zinc	Adequate	58	14	4.801	0.028*
	Inadequate	30	18		
Vitamin B12	Adequate	60	16	3.341	0.068
	Inadequate	28	16		

CONCLUSION

This study had shown that homeless children have adequate intake for energy, iron, and vitamin B12. Most homeless children are categorized in the borderline category for their cognitive performance. There were no associations found between the energy, iron, and Vitamin B12 adequacy and cognitive performance of homeless children except for zinc adequacy.

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