Mal J Nutr 17(1): 19 - 30, 2011

Nutritional Status of Children Living with HIV and Receiving Antiretroviral (ARV) Medication in the Klang Valley, Malaysia

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ABSTRACT

Introduction: Nutrition and HIV are closely related. Any immune impairment as a result of HIV leads to malnutrition, which in turn, can also lead to reduced immunity, thus contributing to a more rapid progression to AIDS. **Methods:** This cross-sectional study determined the nutritional status of children living with HIV and are receiving antiretroviral medication in the Klang Valley. A total of 95 children aged one to eighteen years old were recruited between September 2008 and February 2009. Data collected included socio-economic status, anthropometric measurements, dietary intake, medical history and serum levels of selected micronutrients specific for immunity. **Results:** The mean age of the children was 8.4±3.9 years and the mean duration on antiretroviral medications was 68.3±38.3 months. Anthropometric assessment found that 9.5% of the children were underweight and 31.6% were overweight. In contrast, 20.8% were stunted and 14.6% severely stunted. Biochemical indicators showed that 10.4% had deficiency in vitamin A while 12.5% had deficiency in selenium. Total cholesterol and HDL-C levels were found to be low in 30.5% and 10.5% of the children respectively. **Conclusion:** Dietary assessment showed almost all the children did not achieve the recommended energy intake for their age groups and almost half of the children did not achieve the RNI for selenium and vitamin A. This study provides an insight on the nutritional status of children living with HIV.

Keywords: Antiretroviral (ARV), Human Immunodeficiency Virus (HIV), lipid profile, micronutrients, nutritional status

INTRODUCTION

The term 'children living with HIV' refers to those under the age of 18 years who are infected with HIV. In Malaysia, the total number of children living with HIV reported until December 2009 is 2,122 cases. In 2009, children below 18 years of age made up 3.1% of 3, 080 new reported HIV cases for that year (MOH, 2010). At the same time, the number of infected women has increased drastically in recent years prompting the

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possibility that the number of children infected with the virus may also be on the rise. Undeniably, this epidemic affects people of all ages but with the age of infected people getting younger, the number of years people have to live with the virus also increases, thus making the treatment of HIV more costly than before. This has turned HIV infection from an invariably fatal disease to a chronic, manageable disease in many instances (Palella Jr *et al.*, 2003). As such, it is vital that the progression of the disease is kept slow. One of the strategies to slow or reverse the progression of the virus would be through the integration of nutrition as part of the overall care, support and treatment for HIV and AIDS (Wanke, 2005).

Nutrition and HIV are closely related. HIV damages the immune system, therefore exposing an individual to a range of opportunistic infections and causing them to experience weight loss, fever, diarrhoea and weakening of their immune system until they can no longer fight off other diseases. Any immune impairment as a result of HIV leads to malnutrition, which in turn, can also lead to reduced immunity, thus contributing to a more rapid progression to AIDS. Therefore, malnutrition can both contribute to and be a result of the progression of HIV. An HIV-infected person is also at greater risk of malnutrition owing to difficulty in chewing and swallowing food. In addition, absorption of nutrients may be curtailed, requirements for energy and nutrients may be increased, and metabolism altered, all of which may affect the nutritional status of the infected person (FANTA, 2003).

Combined antiretroviral (ARV) therapy that includes protease inhibitors (PI) has been found to be effective and maintained a lasting reduction of the HIV-viral load, with an improvement in survival and quality of life (Fiore *et al.*, 2000). However, these medications also give rise to a number of side-effects such as lactic acidosis, dyslipidaemia, morphological changes (fat accumulation and lipoatrophy), and dysregulation of glucose metabolism (WHO, 2005).

In Malaysia, little is known about the nutritional status of children living with HIV, thus making it difficult to initiate intervention-based programmes. A baseline nutritional assessment would greatly facilitate and highlight the importance of nutritional needs among these children to medical practitioners and would also provide alternative treatment to further enhance their overall health (Knox *et al.*, 2003). This study aims to determine the nutritional status of children living with HIV currently receiving ARV therapy.

METHODS

The study was carried out at the Paediatric Institute, Kuala Lumpur General Hospital (KLGH) and the Department of Paediatrics, University Malaya Medical Centre (UMMC) involving all the children being treated for HIV.Both hospitals are located in the Klang Valley, which is an area in Malaysia comprising Kuala Lumpur and its suburbs, and adjoining cities and towns in the state of Selangor. The recruitment process took six months – September 2008 to February 2009. The number of children living with HIV being treated at the KLGH totalled 111 and 10 are being treated at the UMMC. In this study, children were recruited after excluding those yet to start ARV treatment, hospitalised due to infections, younger than one year of age, and those who refused to participate or were absent from their appointment. This study utilised a purposive sampling method whereby both the hospitals were selected as they are centres of referral for HIV cases among children below the age of 18 years. All children who met the selection criteria were included. Prior consent was obtained from caregivers (parents / guardians) before their child was accepted for this study.

Ethical clearance was obtained from the Medical Research Ethics Committee of the Faculty of Medicine and Health Sciences,

Universiti Putra Malaysia as well as the Ethical Committee of the Faculty of Medicine, University of Malaya. In addition, approval to conduct this research was obtained from the National Medical Research Registry (NMRR) of the Ministry of Health Malaysia. Subsequent to NMRR granting permission, approval to conduct the research was then obtained from the respective hospitals (KLGH and UMMC).

Data collection

Anthropometric measurements

Anthropometric measurements taken in this study included weight and height of the children. Weight (to the nearest 0.1 kg) was measured using the Tanita digital scale model 314 while height (to the nearest 0.1 cm) was measured using SECA wall stadiometer model 206. Body Mass Index for age (BMI for age), height for age and weight for age were the indicators used to determine the growth status of the children. The WHO Growth Standards 2006 for children aged 0 to 5 (WHO, 2006) and WHO Growth Reference 2007 for children aged above five years (WHO, 2007) were used for classification purposes. BMI for age z-scores (BAZ), Weight for age z-scores (WAZ) and Height for age z-scores (HAZ) were also computed to adjust for age and sex differences.

Medical history

In this section, information such as age at first diagnosis with HIV, duration onARV treatment, types of ARV regimen, and CD4 count were collected from medical records. For CD4 count, the reference point for the disease severity was based on the clinical practice guidelines published by the Ministry of Health, Malaysia (2008).

Biochemical parameters

In this study, serum lipid levels and several micronutrients specific to immunity, namely selenium, zinc, vitamin A, vitamin E and ferritin were selected for examination. A total of 15 ml of blood samples were collected by the nurses at the respective hospitals. Blood samples were kept at room temperature until they were transported to the Gribbles laboratories for analysis. The analyses of selenium, zinc, vitamin A and E levels were done at the Gribbles laboratory in Australia while the analyses of lipid and ferritin levels were done at the Gribbles laboratory in Malaysia in accordance with laboratory-based protocols.

Inductively coupled plasma mass-spectrometry (ICP-MS) was used for the measurement of zinc and selenium levels. As for serum levels of vitamin A and E, high-performance liquid chromatography (HPLC) with UV detector was used. Serum ferritin level was measured using Advia Centaur ferritin based on 2-site sandwich micro-particle immunoassay. Serum triglyceride (TG), total cholesterol (TC) and high density lipoprotein cholesterol (HDL-C) were measured using enzymatic methods. On the other hand, low density lipoprotein cholesterol (LDL-C) was derived by calculation using the Friedewald formula (Friedewald, Levy & Fredrickson, 1972).

The reference values for vitamins and minerals used in this study were based on the laboratory values recommended by the WHO/FAO (2001) for vitamins and minerals. Low serum levels were defined as selenium $< 0.9\mu$mol/L, zinc $< 9.0\mu$mol/L, vitamin A $< 0.70\mu$mol/L and vitamin E $< 25.0\mu$mol/L (WHO/FAO, 2001). As for serum ferritin, reference values from another report by WHO (2001) was used.

Although the best practice would be to have fasting blood sample for the analysis of lipid profile (NCEP/ATP III, 2001), it was not feasible due to the fact that the children were required to take the prescribed regimen of drugs on time with meals. Therefore, it was deemed unethical to require fasting blood samples from these children. Nevertheless, the reading for lipids obtained would still be comparable to that of the

Table 1. Socio-demographic characteristics of the children (n=95)

Characteristics	*Frequency*	*Percentage (%)*
Age (years)		
<5	24	25.3
5.1 – 10.0	41	43.2
10.1 – 15.0	26	27.3
>15.0	4	4.2
Mean ± SD	8.4 ± 3.9	
Median	9.0	
Gender		
Male	54	56.8
Female	41	43.2
Ethnicity		
Malay	51	53.6
Chinese	31	32.6
Indian	5	5.3
Sarawak *Bumiputera*	2	2.1
Sabah *Bumiputera*	1	1.1
Myanmar (Refugees)	5	5.3

NCEP classifications for children and adolescents (1992) except for TG and LDL-C levels. It is also worth noting that the results from this study can only provide an insight for screening purposes and no diagnostic conclusion can be drawn for clinical purposes.

Dietary intake

Dietary data were obtained by means of interview with guardians / caretakers using 24-hour dietary recall method. A two-day dietary intake which comprised one weekday and one weekend was collected and the mean energy intake, carbohydrates, protein, fat and selected micronutrients – calcium, zinc, selenium, iron, vitamin A, and vitamin E– were calculated. Dietary data were analysed using Nutritionist Pro version 2.4 Nutrition Analysis Software (First Data Bank Inc., 2003). Under-reporting of energy is one of the common problems in dietary assessment. In this study, under-reporting of energy intake was calculated. This is based on an estimated ratio by Goldberg, Black & Jebb (1991) which measures the ratio between energy intake (EI) and basal metabolic rate (BMR). An EI / BMR ratio below 1.2 was used as the cut-off for having inadequate energy intake for the maintenance of body weight. This cut-off value was found to be appropriate for use among children as well as adults (Gibson, 2005; Goldberg *et al*., 1991).

Data analysis

All data were analysed using SPSS for Windows version 17.0 and are presented descriptively.

RESULTS

Socio-demographic background

A total of 95 children were recruited into this study. The age of these children ranged from 15 months to 17 years. More than two-thirds (70.5%) of the children recruited were between 5 and 15 years and the mean age was 8.4 ± 3.9 years (Table 1). While 64.2% of the children lived with families, 8.4% were adopted and 27.4% were living in shelter homes around Klang Valley.

Anthropometric measurements

Body Mass Index-for-age (BMI-for-age) indicates that majority of the children had normal weight (55.8%). Approximately 9.5% of the children were underweight whereas 31.6% of the children were overweight. Furthermore, three children were found to be obese. Weight-for-age was used to determine the current growth status of the children below 10 years of age where the majority (79.7%) were found to have normal weight-for-age while 17.0% of the children were found to be wasted (WAZ < -2 S.D.). For long-term growth (height for age), it was found that 21.1% of the children were stunted (-3 S.D. ≤ HAZ < -2 S.D.) and 14.7% were severely stunted (HAZ < -3 S.D.). More females (39.0%) than males (33.3%) were stunted. The mean BAZ, HAZ and WAZ for males and females were -0.53±0.16 and -0.54±0.20, -1.77±0.15 and -1.72±0.20, -1.21±0.18 and -1.17±0.27 respectively.

Medical history and immune status

Most children were diagnosed with HIV in the first two years of life (61.5%) and the mean age of first diagnosis was 28.3 ± 33.6 months. The average number of months the children had been on ARV was 68.3 ± 38.3 months. Only 4.2% had been on the regimen for less than a year while 33.3% had already been on the regimen for 4-6 years. This was followed by those currently on treatment between 1-3 years which made up 27.0% while those who had been on the regimen for 7 to 9 years were 24.0% and 11.5% had been on the regimen for more than ten years.

With reference to the HIV-associated immuno-deficiency status using CD4 count (absolute count or %) (Ministry of Health Malaysia, Academy of Medicine Malaysia & Malaysian Paediatric Association, 2008), it was found that 72.6% were considered to have good immune status with little or no suppression. On the other hand, 7.4% were found to be severely affected and immuno-suppressive. A high percentage was found to have good immune status which could be partly attributed to the use of ARV medications. In terms of ARV therapy used, a combination of more than one type of drug is used for all children. Almost half (44.2%) were taking PI being either Kaletra or Ritonavir. The prescription of the drugs indicates that it is in line with the consensus on ARV treatment by the MOH with combination therapy of either Zidovudine and Lamivudine or Zidovudine and Didanosine as the preferred choice of treatment (Ministry of Health Malaysia, Academy of Medicine Malaysia & Malaysian Paediatric Association, 2008). Also, a combination therapy that includes a PI is also virologically and immunologically more superior to dual nucleoside combination therapy.

Biochemical parameters

The mean serum concentration of the selected micronutrients and lipid content is presented in Table 2. The lowest serum levels detected for selenium, zinc, vitamin A, and vitamin E were 0.60μmol/L, 7.40μmol/L, 0.48μmol/L and 11.70μmol/L respectively. It is worth noting that the reference values used are just for comparison and only provide an insight for screening purposes and no diagnostic conclusion can be drawn for clinical purposes.

Although it is acknowledged that non-fasting blood was used for analysis, TC and HDL-C levels would still be considered to be comparable as the readings were not affected by a post-prandial hike in TG level (Deeg, 2005). Note that two cases were excluded for the computation of LDL-C due to excessively high TG levels which rendered the estimation to be not valid. Upon examination of the lipid profile, borderline high and high TC levels were found among 33.7% and 30.5% of the children respectively. Meanwhile,10.5% had lower than normal HDL-C levels in comparison to NCEP classifications (1992). The results (cited as ranges) for TC, TG, LDL-C and HDL-C were 2.60 – 8.60mmol/L, 0.37 – 5.92 mmol/L, 1.32

Table 2. Serum level of selected micronutrients and lipid profile of the children

	Mean±SD	*Deficient/Low* (%)*
Selenium (μmol/L)	1.13 ± 0.24	12.5
Zinc (μmol/L)	11.69 ± 1.88	6.2
Vitamin A (μmol/L)	1.14 ±0.36	10.4
Vitamin E (μmol/L)	29.84 ± 7.42	1.1
Ferritin (μg/L)	91.54 ± 195.48	4.2
Lipid Profile:	Mean±SD	High** (%)
TC (mmol/L)	4.72 ± 0.89	30.5
TG (mmol/L)	1.61 ± 1.00	N.C.
LDL-C (mmol/L)	2.67 ± 0.71	N.C.
	Mean±SD	Low** (%)
HDL-C (mmol/L)	1.34 ± 0.31	10.5

* With reference to WHO (2001): laboratory recommended values for selenium, zinc, vitamin A & E and WHO (2001): reference values for serum ferritin
** With reference to NCEP (1992)
N.C. – Not comparable due to non-fasting blood samples

– 5.97 mmol/L and 0.65 – 2.34 mmol/L respectively.

Dietary intake

Five cases were excluded from the dietary analysis due to high missing values and poor data quality. It was found that 39.6% of the respondents under-reported their mean energy intake as calculated using the Goldberg's equation (Goldberg *et al.*,1991). However, they were not excluded from the study as the aim of the study is to present the overall energy and nutrients intakes of all samples obtained. Table 3 shows the mean intake of energy and macronutrients among the respondents. It is apparent that only those children aged between 1 to 3 years met their recommended energy intake with reference to the Recommended Nutrients Intake for Malaysians (NCCFN, 2005). It is also worth noting that as the children became older, bigger differences between their intake and their recommended requirements were observed. However, these might also be attributed to the high percentage of under-reporting among the children. In terms of macronutrients, 65.2% of the respondents had less than 55% of their energy from carbohydrate sources and thus protein and fat intake were in excess among most of the age groups with 78.7% having more than 15% of energy from protein sources and 53.9% having more than 30% of energy from fat sources.

As seen in Table 4, most of the children did not meet the requirements for Zinc and vitamin E for their respective age groups but not for Selenium and vitamin A. However, even though the dietary intake of vitamin A was found to be sufficient for most of the children, 33.7% were found to be having subclinical deficiency and another 11.6% were deficient in serum vitamin A. On the other hand, upon examination of their serum level of vitamin E, 26.3% were found to be deficient in vitamin E with their intake being inadequate.

DISCUSSION

Children living with HIV are commonly seen to have abnormalities in growth and

Table 3. Energy and macronutrients intake by demographic background (n=90)

Age groups (in years)	Energy Intake (kcal)						Carbohydrate Intake (g)				Protein Intake (g)						Fat Intake (g)			
	Boys (n=48)			Girls (n=42)			Boys (n=48)		Girls (n=42)		Boys (n=48)			Girls (n=42)			Boys (n=48)		Girls (n=42)	
	Mean	± SD	RNI*	Mean	± SD	RNI*	Mean	± SD	Mean	± SD	Mean	± SD	RNI*	Mean	± SD	RNI*	Mean	± SD	Mean	± SD
1-3	1081.9	347.1	980.0	1188.7	246.1	910.0	138.3	63.6	141.8	29.6	50.9	20.2	17.0	55.0	13.3	17.0	36.7	20.1	44.8	14.9
4-6	1224.1	457.5	1340.0	1216.6	291.1	1290.0	147.5	53.5	160.7	55.8	58.1	23.2	23.0	52.2	19.4	23.0	45.5	20.8	41.8	14.6
7-9	1307.3	395.4	1780.0	1336.8	243.7	1590.0	177.0	50.1	177.4	33.1	51.8	20.5	32.0	60.6	25.5	32.0	43.9	19.0	42.8	11.1
10-12	1244.8	300.3	2180.0	1415.9	565.3	1990.0	162.4	37.7	190.6	110.2	57.6	17.4	45.0	66.7	30.5	46.0	41.6	16.5	45.0	17.9
13-15	1602.9	594.9	2690.0	1585.8	556.6	2180.0	195.2	73.2	234.0	109.3	74.8	30.6	63.0	69.3	23.4	55.0	59.0	23.6	42.2	14.1
16-18	2174.3	200.3	2840.0	1113.8	741.6	2050.0	244.5	6.2	165.4	93.9	117.5	5.4	65.0	55.8	45.3	54.0	81.9	24.3	26.6	22.3

* Values from Recommended Nutrient Intake (RNI) for Malaysia (NCCFN, 2005)

Table 4. Micronutrients intake by demographic background (n=90)

Age groups (in years)	Zinc (mg)						Selenium (µg)						Vitamin A (RE)						Vitamin E (mg)					
	Boys (n=48)			Girls (n=42)			Boys (n=48)			Girls (n=42)			Boys (n=48)			Girls (n=42)			Boys (n=48)			Girls (n=42)		
	Mean	SD ±	% RNI*	Mean	SD ±	% RNI*	Mean	SD ±	% RNI*	Mean	SD ±	% RNI*	Mean	SD ±	% RNI*	Mean	SD ±	% RNI*	Mean	SD ±	% RNI*	Mean	SD ±	% RNI*
1-3	2.7	1.9	66.0	2.6	.9	63.4	12.5	10.9	73.3	17.5	22.7	102.7	741.5	397.7	185.4	852.5	171.1	213.1	2.6	1.3	52.2	4.1	1.0	81.8
4-6	3.4	2.8	65.8	1.9	1.1	37.8	23.1	19.0	109.9	22.3	18.1	106.2	827.3	570.8	183.8	518.1	301.8	115.1	3.0	1.9	59.3	2.4	1.7	48.1
7-9	2.4	1.9	41.0	3.8	3.1	65.6	22.8	18.3	103.8	25.8	17.7	117.4	534.6	284.1	106.9	582.0	357.8	116.4	3.2	3.1	45.6	4.1	2.4	58.2
10-12	4.1	2.2	45.1	3.2	2.5	42.5	27.7	17.3	98.9	28.1	18.9	122.2	610.7	366.1	101.8	515.6	197.6	86.0	3.1	1.7	30.6	3.2	2.9	42.3
13-15	3.4	0.9	37.3	6.8	9.8	91.2	32.7	7.2	116.7	30.0	16.6	130.4	542.4	407.8	90.4	524.1	193.4	87.4	3.9	.8	39.5	4.1	5.2	55.1
16-18	6.9	4.2	77.3	2.7	1.6	36.0	69.0	38.6	246.5	28.6	14.4	124.3	1660.6	826.5	276.8	538.1	250.8	89.6	5.2	3.5	51.7	2.4	1.5	32.1

* % RNI – The mean percentage of RNI achieved (NCCFN, 2005)

metabolism. One of the first manifestations of HIV infection in children is poor growth and this could have a significant effect on short-term as well as long term survival (Nachman *et al*., 2005; Oleske & Czarniecki, 1999). A study by Newell, Borja& Peckham (2003) showed that infected children were also estimated to be significantly shorter and lighter than non-infected children with increasing growth differences with age. Similarly, poor growth was seen among the respondents in this study with 34.8% of stunting reported. In comparison to non-infected Malaysian children aged 0 to 18 years, the national prevalence of stunting was 15.8% (IPH, 2008). A recent study in Thailand among 388 HIV / AIDS orphans aged 6 to 12 years found that HIV-infected children had significantly higher proportions of stunting and underweight as compared to other HIV / AIDS orphans who are not positive (Isaranurug & Chompikul, 2009). The higher prevalence of stunting among the infected children indicates the need for nutritional interventions to forestall the retardation of growth and progression of the disease. On the other hand, a small number of children in this study were found to be overweight and obese. Studies looking at the association between HIV infection and obesity among children are relatively limited but a review on adults indicate that adults living with HIV are gaining weight and beginning to approach weight levels seen in the general U.S. population (Keithley*et al*., 2009). One plausible explanation for this finding may be due to the use of ARV treatment that may have positive effects on their nutrition as well as in promoting weight gain in terms of fat mass, fat free mass and body cell mass (Fiore *et al*., 2000).

Micronutrient deficiencies are common in HIV, both in the early as well as the late stages of the progression of the infection (Bogden & Oleske, 2007; Patrick, 2000). The biochemical markers examined in this study showed deficiency in several micronutrients. In this study, deficiency in serum levels of selenium and vitamin A were more common as compared with other micronutrients. Low status of micronutrients seen in early asymptomatic HIV is mainly due to reduced absorption as a result of structural and functional changes of the intestinal tract which is characterised by villous atrophy and crypt hyperplasia (Ullrich *et al*., 1989), increased utilisation and loss of micronutrients when diarrhoea and other co-infections become more frequent (WHO, 2005). As such, intake becomes increasingly important and its level of requirement may eventually be higher than that of normal non-infected children.

Selenium deficiency is associated with immune dysfunction, impaired resistance to microbial and viral infections, inadequate phagocytosis and antibody production, natural killer cell cytodestruction and decreased CD4 cell count (Baum & Campa, 2006; Fawzi, 2003). Although the dietary intake of selenium is relatively adequate and mostly achieved the recommended nutrient intake (RNI) for their age groups, selenium deficiency in serum was relatively high (12.6%)among HIV-infected children in the present study.Theoretically, this could be due to the existence of a selenium-based homolog of glutathione peroxidase produced by HIV (Taylor, Nadimpalli & Ramanathan, 1997). It is known that the virus accelerates the depletion of selenium from HIV-infected lymphocytes, allowing the virus to replicate at the expense of the CD4 cells. Another plausible reason could be related to the methodological limitation, that is, the serum is only one of the many compartments where the nutrient can be found. Furthermore, oxidative stress may alter the serum level owing to the use of the nutrient as an antioxidant and thus diminishing the correlations between dietary intake and serum level (Baum & Campa, 2006; Potischman, 2003).

Similarly, serum level of vitamin A as measured in retinol equivalent (RE) was found to be deficient in 11.6% of the children whereas dietary assessment indicated that most of the children achieved the RNI for

vitamin A. Deficiency in vitamin A was found to be common in HIV infection, and serum levels appear to decrease as the disease progresses (Fawzi *et al*., 2000; Patrick, 2000). Low serum retinol levels could also be a result of impaired ability of the liver to mobilise vitamin A due to the inflammatory response initiated by infection thereby contributing to depletion at the serum level (Alvarez *et al*., 1995; Kassu *et al*., 2007). Besides, a study by Karter*et al*. (1995)found that the development of vitamin A deficiency does not appear to depend on dietary intake as 27% of the children in their study had low retinol levels even though they were judged to have an 'adequate intake' of vitamin A. This finding is similar to that found in the current study, thus confirming that adequate dietary intake of vitamin A may not be reflected in plasma.

In HIV infection, zinc has a role as an antioxidant, immune-modulator as well as a possible direct anti-viral agent (Bogden & Oleske, 2007; Sprietsma, 1999). Zinc deficiency is thought to reduce the generation of T cells and depresses the humoral and cell-mediated immunity (Baum *et al*., 2003). The prevalence of zinc deficiency among the respondents was relatively low with only 6.3% although in terms of dietary intake, only approximately 50% of the RNI for zinc was achieved by most of them. Such contradictory findings may be associated with several factors. Methodological limitations again play a role in the assessment of zinc adequacy. Zinc is mostly stored in muscles and liver, but it is not possible to obtain specimens from these sites. Only a small percentage of zinc is found in the serum, which is generally not a sensitive marker of zinc status and thus not a good reflection of immune impairment. There is also a lack of an established functional or enzymatic marker of zinc status (Gibson *et al.*, 2008; King & Keen, 1994).

As with adults, dyslipidemia is associated with the use of PI. It includes elevated TC, TG, and LDL-C and decreases in HDL-C(Lainka *et al*., 2002). In a study examining the changes on nutritional status of HIV-infected children receiving combined ARV therapy in Italy, 70% of the children receiving ritonavir (a type of PI) had hyperlipidemia (Fiore *et al*., 2000). Similarly, a study conducted by Farley *et al*.(2005) found that the prevalence of hypercholesterolemia was 13.0% among 1812 perinatally HIV-infected children aged between 4 to 19 years and PI was attributed as the strongest associated risk factor. Another study among 30 children with AIDS on ARV therapy noted that 60% of the children were having dyslipidemia(Beraldo Battistini *et al*., 2010). Thus, it is not surprising that 30.5% of the children in this study were having high TC level, given that they are all on ARV therapy.

There are several limitations with regard to this study. First of all, we did not take into consideration the level of physical activity among the children. As such, the pattern of energy expenditure could not be estimated. Besides, the use of supplements was not studied. The use of supplementation could possibly mask the actual nutrient store in the body. This is because serum level used in this study may not be the best indicator since it only provides a snapshot of time and thus may not represent the actual bodily store of the micronutrients. Furthermore, the findings could not be generalised to all the children living with HIV in Malaysia due to the nature of the cross-sectional study design.

This study has thrown up many questions in need of further investigation. First, further understanding of the mechanisms that contribute to excessive weight gain among children receiving ARV therapy may provide substantial information on ways such unwarranted weight gain can be controlled. Furthermore, it would be interesting to compare the nutritional status of those yet to start ARV therapy to have a better understanding on how nutrition can play a role in delaying the initiation of the therapy as well as making the therapy more effective in

prolonging the lives of these children. It is also vital to note that the quality of life of these children should not be neglected in the process of prolonging their lives as the lack of either one may hinder efforts to provide them a better chance of leading a normal life. Last but not least, considerably more work will need to be done especially in efforts to develop a minimally invasive, valid and reliable tool to assess their nutritional status and thus enable early detection of any nutritional problem.

CONCLUSION

In conclusion, poor growth as depicted by the high prevalence of stunting in children living with HIV is common and it has a significant adverse effect on the long-term survival and overall health status of the children. The cause of abnormalities in growth may be multifactorial and these include inadequate dietary intake, the presence of acute infections, loss of appetite, drug side effects, hypercatabolism and malabsorption. Micronutrient deficiencies are also common among these children, particularly those related to immune regulation as well as antioxidants. This could be a result of malabsorption as well as virally-caused depletion and altered metabolism.

ACKNOWLEDGEMENTS

This study was funded by UNAIDS. The authors would like to extend their deepest appreciation to the children and their caregivers for their participation as well as to Staff Nurse NikFaridah binti Nik Abdul Rahman of KLGH for her assistance.

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