

Intakes and adequacy of potentially important nutrients for cognitive development among 5-year-old children in the Seychelles Child Development and Nutrition Study

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Abstract

Objective: To assess the nutritional adequacy of Seychellois children in relation to nutrients reported to be important for cognitive development.

Design: Dietary intakes were assessed by 4 d weighed food diaries and analysed using dietary analysis software (WISP version 3.0; Tinuviel Software, UK). Individual nutrient intakes were adjusted to usual intakes and, in order to investigate adequacy, were compared with the UK Estimated Average Requirements for children aged 4–6 years.

Setting: Children 5 years old were followed up as part of the Seychelles Child Development Nutrition Study (SCDNS), located in the high-fish-consuming population of Mahé, Republic of Seychelles.

Subjects: Analysis was carried out on a sample of 229 children (118 boys, 111 girls).

Results: Children consumed a diet of which fortified cereal and milk products contributed the most to nutrient intakes. The majority ($\geq 80\%$) of children met requirements for several nutrients important for child development including Fe, folate and Se. Adjusted dietary intakes of Cu, Zn, iodine, niacin and vitamin A were below the Estimated Average Requirement or Recommended Nutrient Intake. Mean adjusted energy intakes (boys 4769 kJ/d (1139.84 kcal/d), girls 4759 kJ/d (1137.43 kcal/d)) were lower than the estimated energy requirement (boys 5104 kJ/d (1220 kcal/d), girls 5042 kJ/d (1205 kcal/d)) for 88% of boys and 86% of girls.

Conclusions: Nutrition was adequate for most children within the SCDNS cohort. Low intakes of some nutrients (including Zn, niacin and vitamin A) could reflect nutritional database inaccuracies, but may require further investigation. The study provides valuable information on the adequacy of intakes of nutrients which could affect the growth and development of Seychellois children.

Keywords
Dietary intakes
Nutrient adequacy
Child nutrition
Cognitive development

Nutrition during early childhood has an important and long-lasting influence on child growth and cognitive development^(1–3). Brain growth and development is most rapid and critical during the first 2 years of life, but development of the frontal lobes continues throughout early childhood^(4,5). Certain nutrients make important contributions to optimum brain and neurological function including Zn, Fe, iodine, folate, Se and long-chain PUFA⁽⁵⁾. Many of these nutrients are involved in metabolic processes such as the production of enzymes or essential cofactors, some of which are central to brain growth and

development^(6,7). Zn is recognised as important for growth and neurodevelopment, and low intakes have been associated with behavioural problems such as attention-deficit hyperactivity disorder in children⁽⁸⁾. Fe and iodine are critical nutrients in early brain development, but deficiencies are commonplace among school-aged children in both developing and developed countries and are a major cause of impaired motor skills and cognitive function^(1,9). Folate and vitamin B₁₂ are necessary for the methylation pathway, an integral process to the synthesis of DNA and neurotransmitters, while Se contributes to thyroid hormone

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synthesis and may affect mood^(1,6). There is evidence that DHA (*n*-3 PUFA) and arachidonic acid (*n*-6 PUFA), long-chain PUFA which are most important during fetal and infant development, can offer postnatal benefits to child performance and behaviour^(10–12).

A poor diet during childhood may be associated with low intakes of these nutrients and evidence from longitudinal studies suggests that dietary habits formed in childhood can often continue into later life^(13,14), thus highlighting the importance of assessing childhood diet. Assessment of nutrient adequacy, which has been defined as intake of nutrients which either meets or exceeds the appropriate Dietary Reference Value (DRV) for that population without being excessive⁽¹⁵⁾, is a useful tool in dietary surveys of children.

An additional interesting aspect of the relationship between nutrition and child development described by Strain *et al.*⁽¹⁶⁾ is the suggestion that nutrients in fish may ameliorate the potentially neurotoxic effects of methylmercury exposure. This issue is of special concern within high-fish-eating populations such as the Republic of Seychelles. For this reason, the Seychelles Child Development Nutrition Study (SCDNS) is investigating nutritional intakes and status of pregnant women and their children. The aim of the current study was to analyse dietary intakes and investigate adequacy of potentially important nutrients for cognitive development among 5-year-old Seychellois children.

Experimental methods

Participants

The present study is a follow-up analysis of children born to mothers initially recruited for the SCDNS. In 2001, a total of 300 pregnant women were recruited within Mahé, the main island of the Republic of Seychelles. This cohort was considered representative of the Seychelles population owing to study design and recruitment, which have been described in detail previously⁽¹⁷⁾. As part of that longitudinal study, offspring of the women were re-evaluated in 2006 when they were approximately 5 years old. There were complete dietary data for a total of 229 children who participated in the follow-up study. The study was reviewed and approved by the appropriate Research Subjects Review Boards of collaborating partners, the Ministry of Health of Seychelles and the University of Rochester.

Dietary assessment

Dietary intakes were assessed using two weighed 4d food diaries, of which one was supplied to parents/guardians and the other to teachers, who were requested to keep records of each child's food intake over four consecutive days (two weekdays and two weekend days) when at home and at school. Diet diaries were available

in both English and Creole languages. Both parents/guardians and teachers were supplied with Ravenscourt weighing scales to assist with recording portion weights of food and drinks consumed by the children, including information on amount, brand, recipe and preparation method used. When it was not possible to weigh meals received at school, researchers and trained nutritionists in the Seychelles assisted with calculating portion sizes of meals eaten by the children during school hours. Nutritionists in the Seychelles reviewed the diaries within one week of completion, with any errors and omissions being clarified with children and their families. Researchers also visited the family home/school frequently to monitor the weighing and recording of foods by respective parents/guardians and teachers. Food and nutrient intakes were analysed using the nutrient database package WISP version 3.0 (Tinuviel Software, Warrington, UK), which contains data from the UK Nutrient Databank⁽¹⁸⁾ and was previously supplemented with food composition and recipe data for foods typical to the Seychelles diet⁽¹⁹⁾. In the present study, the WISP database was further augmented with food composition data of foods commonly consumed by Seychellois children. Owing to incomplete PUFA composition data for all fish species, it was not possible to analyse PUFA intakes accurately within the study.

Dietary data were coded into seventeen food groups and expressed as g/d: cereal & cereal products; milk & milk products; eggs; vegetables; fruit; sugars, preserves & snacks; white fish; fatty fish; crustaceans; molluscs; fish products & dishes; red meat; white meat; meat products & dishes; fats and oils; beverages; and other foods (which included the sum of herbs & spices, nuts & seeds, soups, sauces & miscellaneous foods). Fish were classified as being white (lean) or fatty based on knowledge of their total fat and fatty acid content⁽²⁰⁾. For five children, dietary records were available only for three of the four surveyed days; therefore all calculations for these children were modified according to the three recorded days. Children's heights and weights were measured according to standardised procedures by nutritionists, using calibrated equipment at the Child Development Centre in Seychelles, and BMI was calculated as [weight (kg)]/[height (m)]².

Assessing validity of energy intake

In order to assess the validity of reported energy intake (EI_{rep}) in dietary surveys of children, it is important to use appropriate cut-offs for both age and sex in order to account for variability in growth and physical activity⁽²¹⁾. In the present study, the method described by Black and Cole⁽²²⁾ for evaluating energy intakes was employed. Energy expenditure (EE) was estimated using published sex- and age-specific equations which were developed using doubly labelled water data measured in children of a similar age⁽²³⁾.

A low active physical activity level (PAL = 1.4–1.6) was assumed for all children based on doubly labelled water data⁽²⁴⁾, which allowed a constant corresponding physical activity coefficient value of 1.16 to be used in these equations. The estimated energy requirement (EER) was calculated as the EE + 84 kJ/d (20 kcal/d)⁽²³⁾. The validity of EI_{rep} was then assessed against EE by use of the EI_{rep}:EE ratio and by obtaining a 95% confidence limit for the agreement between these two measurements. In order to calculate the confidence limit, the within-subject CV for EI_{rep} and EE were initially calculated and the mean value for both the CV of EI_{rep} (CV_{EI}) and the CV of EE (CV_{EE}), taken as 8.2% for the present study⁽²²⁾, were used to calculate a combined CV (CV_C):

$$CV_C = \sqrt{(CV_{EE}^2 + CV_{EI}^2)/d}$$

where *d* is the number of days of dietary assessment. The acceptable range, or confidence limit, for EI_{rep}:EE was then calculated as:

$$EI_{rep}: EE < \text{mean } EI_{rep}: EE + CV_C$$

$$EI_{rep}: EE > \text{mean } EI_{rep}: EE - CV_C$$

Those children with a ratio below this limit were then classified as under-reporters, while normal reporters were classified as those children with an EI_{rep}:EE within the acceptable range.

Assessment of nutritional adequacy

Nutritional adequacy was evaluated by applying a statistical equation to adjust the distribution of nutrient intakes reported from the 4 d assessment period, thus correcting for intra-individual variability which creates inaccuracies in dietary assessment⁽²⁵⁾. Adjusted nutrient intakes were then compared with the Estimated Average Requirement (EAR) according to UK DRV^(25,26) for healthy children of the same sex and age. In the absence of specific nutritional guidelines existing for the Seychelles population, the UK DRV have been used and these DRV are considered to be appropriate guidelines for this population⁽¹⁷⁾. The EAR is known as the best reference value with which to examine the prevalence of inadequate nutrient intakes within a group⁽²³⁾. This method has been described as the most accurate compared with alternative methods of assessing nutrient adequacy⁽²⁷⁾. In the case of Na, K, Cu, Se and iodine, the Recommended Nutrient Intake (RNI) has been used for comparison in the absence of an established EAR. The RNI, however, can only be used to estimate nutritional adequacy for intakes above, but not below, this level⁽²⁵⁾. Furthermore, the EAR cut-point method cannot be used to assess energy intakes, as this approach would break a statistical assumption of the method, namely that the nutrient intake is not related to requirement⁽²⁸⁾. Therefore we compared energy intakes against the group mean EER instead. Nutrient inadequacy was evaluated as the percentage of children with adjusted intakes below the EAR.

Statistical analysis

Statistical analyses were conducted using the SPSS for Windows statistical software package version 18.0 (SPSS Inc., Chicago, IL, USA). Data for all variables were initially tested for normality prior to analysis and descriptive data were expressed as means and standard deviations or medians and 5th, 95th percentiles as appropriate. Nutrient intakes were adjusted using a method described by Beaton⁽²⁹⁾, where within- and between-individual variations in nutrient intakes were calculated before applying the equation:

$$\begin{aligned} \text{Adjusted nutrient intake} = & \\ & (\text{Individual mean intake} - \text{group mean intake}) \\ & \times [(\text{SD individual}/\text{SD group}) + \text{group mean intake}] \end{aligned}$$

These intakes were then compared with the UK EAR for each nutrient by calculating the percentage of children with intakes below this level. Independent *t* tests and one-sample *t* tests were used to determine differences in intakes between boys and girls and between the group including and excluding under-reporters, respectively. In all instances, a two-tailed *P* value of ≤0.05 was considered statistically significant.

Results

Participant characteristics

The group consisted of 118 boys and 111 girls. Their mean age was 5.62 (SD 0.31) years and their mean height and weight values (1.15 (SD 0.05) m) and 19.99 (SD 3.79) kg) were above the 75th percentiles for height and weight according to the Seychelles growth curve data for children. The mean BMI of the boys (15.05 (SD 1.97) kg/m²) and girls (15.02 (SD 2.08) kg/m²) was between the 50th and the 75th percentiles for BMI, placing them within the normal height for weight category for their age group. Using specific height and weight data for each child, the mean EE was estimated at 6121 (SD 586) kJ/d (1463 (SD 140) kcal/d). The mean EI_{rep} and daily variance in energy intake were 4841 (SD 1364) kJ/d (1157 (SD 326) kcal/d) and 27.75%, respectively, which gave a 95% confidence limit of the agreement between EI_{rep}:EE of 0.63–0.95. According to this cut-off, 21% of children were classified as under-reporters (*n* 49) and 79% as normal reporters (*n* 180).

Energy and nutrient intakes

Table 1 presents mean dietary intakes of energy and nutrients for the entire cohort (*n* 229) and separately for the group excluding under-reporters (*n* 180). When mean nutrient intakes were compared between these groups, intakes of energy, protein, fat, K, Zn and thiamin were significantly higher (*P* < 0.05) in the group which excluded under-reporters. Under-reporting did not have an effect on intake of any other nutrient and there were no

Table 1 Estimated daily intakes of energy and nutrients showing the effect of dietary under-reporting among 5-year-old Seychellois children, Seychelles Child Development Nutrition Study (SCDNS), 2006

Nutrient	Including under-reporters (<i>n</i> 229)		Excluding under-reporters (<i>n</i> 180)		<i>P</i> *
	Mean	SD	Mean	SD	
Energy					
kJ/d	4839	1365	5240	1224	0.002
kcal/d	1156.54	326.32	1252.35	292.59	0.002
Macronutrients					
Protein (g/d)	39.37	11.71	42.29	11.07	0.004
Fat (%E)	33.27	4.83	33.58	4.91	0.039
Carbohydrate (%E)	52.06	5.32	51.85	5.25	0.218
Fibre (g/d)	4.38	1.96	4.71	1.98	0.622
Minerals					
Na (mg/d)	1535.53	1224.97	1668.94	1342.06	0.833
K (mg/d)	1191.82	377.05	1287.13	348.70	0.001
Ca (mg/d)	452.72	194.85	493.50	193.23	0.770
Mg (mg/d)	113.25	37.76	123.02	35.46	0.058
Fe (mg/d)	6.41	2.57	6.96	2.55	0.930
Cu (mg/d)	0.53	0.21	0.57	0.20	0.941
Zn (mg/d)	4.31	1.42	4.64	1.33	0.044
Se (µg/d)	33.59	13.19	35.48	13.49	0.503
Iodine (µg/d)	61.56	29.19	66.19	29.52	0.286
Vitamins					
Vitamin A (µg/d)	222.71	148.31	245.87	157.95	0.323
Thiamin (mg/d)	0.69	0.27	0.76	0.26	0.017
Riboflavin (mg/d)	0.79	0.36	0.86	0.36	0.691
Niacin (mg/d)	8.46	3.21	9.13	3.13	0.180
Vitamin B ₆ (mg/d)	0.88	0.32	0.96	0.31	0.212
Folate (µg/d)	135.14	59.52	147.00	59.45	0.870
Vitamin B ₁₂ (µg/d)	2.04	0.85	2.16	0.79	0.274
Vitamin C (mg/d)	66.86	37.34	71.07	37.23	0.452
Vitamin D (µg/d)	2.14	1.17	2.32	1.22	0.676
Vitamin E (mg/d)	6.80	2.87	7.39	2.86	0.476

%E, percentage of total energy intake.

**P* < 0.05 indicates a significant difference in nutrient intakes between all children including under-reporters (*n* 229) and children excluding under-reporters (*n* 180), as assessed by a one-sample *t* test.

significant differences in nutrient intakes between boys and girls. We therefore carried out the following analyses of nutrient adequacy on the entire cohort (*n* 229) in order to include as many valid dietary entries as possible and because the detected degree of under-reporting impacted only some nutrient intakes.

Nutrient adequacy

Table 2 presents adjusted nutrient intakes for the entire cohort (*n* 229) and for boys (*n* 118) and girls (*n* 111) separately, showing the proportion with inadequate intakes below the UK EAR. Although only adult guideline intakes exist for total fat and carbohydrate (33% and 47% of daily energy) within the UK DRV, adjusted mean intakes of all children met these guidelines. Every child met recommended protein requirements, while ≥86% of children were deemed as having adequate intakes of many nutrients, namely K, Ca, Mg, Fe, Se, thiamin, riboflavin, folate and vitamins B₁₂ and C. Adjusted mean energy intakes of boys (4769 (SD 524) kJ/d (1139.84 (SD 125.15) kcal/d)) and girls (4759 (SD 633) kJ/d (1137.43 (SD 151.41) kcal/d)) fell below the EER by 439 and 423 kJ/d (105 and 101 kcal/d), respectively. Compared with the EAR, ≥92% of children were found to have inadequate

intakes of Zn, vitamin A and niacin and a further 30% of boys and 23% of girls, respectively, had vitamin B₆ intakes below the EAR. A large proportion of children (≥86%) were found to have intakes below the RNI for Cu and iodine. The RNI for vitamin D among this age group is set at zero, as it is expected that children's requirements will be met through exposure to sunlight⁽³⁰⁾. Adequacy of vitamin E intakes was also not assessed in this age group given that there exists only a safe intake level for vitamin E for infants in the UK⁽²⁶⁾. There were no significant differences in the number of children with inadequate intakes between boys and girls; however, adjusted mean intakes of vitamin E were significantly greater in girls than boys (*P* = 0.05).

Consumption of food groups and contribution to nutrient intakes

Table 3 shows the children's reported daily intake of food groups and the contribution of food groups to energy, protein and nutrients which are potentially important for cognitive development. Children consumed most food groups, with cereal products, milk products and fruit being the major food groups in the diet for all consumers. These food groups were consumed by children in daily

Table 2 Adjusted energy and nutrient intakes compared with the UK EAR as a cut-off point for assessing nutrient adequacy among 5-year-old Seychellois children, Seychelles Child Development Nutrition Study (SCDNS), 2006

Nutrient	All (n 229)		Boys (n 118)		Girls (n 111)		UK EAR*	% with intakes below the EAR	
	Mean	SD	Mean	SD	Mean	SD		Boys (n 118)	Girls (n 111)
Energy									
kJ/d	4764	578	4769	524	4759	633	Boys: 5104 Girls: 5042	88	86
kcal/d	1138.67	138.19	1139.84	125.15	1137.43	151.41	Boys: 1220 Girls: 1205	88	86
Macronutrients									
Protein (g/d)	39.52	4.53	39.57	5.06	39.48	3.90	14.80	0	0
Fat (%E)†	33.47	2.38	33.18	1.48	33.77	3.03	33.00	–	–
Carbohydrate (%E)†	51.98	2.16	52.17	1.81	51.77	2.46	47.00	–	–
Fibre (g/d)†	4.28	1.02	4.33	1.05	4.22	0.97	18.00	–	–
Minerals									
Na (mg/d)‡	1365.28	949.19	1351.89	524.58	1379.52	1254.75	700.00	8	10
K (mg/d)‡	1186.85	145.23	1185.53	139.14	1188.25	152.06	1100.00	14	12
Ca (mg/d)	437.69	117.18	432.38	139.97	443.25	86.93	350.00	9	13
Mg (mg/d)	108.94	27.73	108.66	32.31	109.24	21.99	90.00	9	12
Fe (mg/d)	6.26	1.61	6.18	1.99	6.34	1.06	4.70	8	6
Cu (mg/d)‡	0.51	0.14	0.51	0.13	0.51	0.15	0.60	88	86
Zn (mg/d)	4.31	0.57	4.33	0.69	4.29	0.41	5.00	92	96
Se (µg/d)‡	33.50	6.93	33.27	7.83	33.75	5.85	20.00	2	4
Iodine (µg/d)‡	59.38	19.48	59.41	23.40	59.35	14.28	100.00	98	100
Vitamins									
Vitamin A (µg/d)§	211.05	105.55	217.55	99.99	204.15	111.18	300.00	94	95
Thiamin (mg/d)	0.69	0.11	0.69	0.12	0.69	0.10	0.30	1	1
Riboflavin (mg/d)	0.74	0.59	0.72	0.82	0.76	0.18	0.60	11	11
Niacin (mg/d)	8.39	1.48	8.48	1.29	8.29	1.64	11.00	97	96
Vitamin B ₆ (mg/d)	0.86	0.17	0.85	0.18	0.87	0.15	0.90	30	23
Folate (µg/d)	131.93	34.55	132.61	3.85	131.21	35.42	100.00	9	9
Vitamin B ₁₂ (µg/d)	2.04	0.43	2.08	0.49	1.99	0.37	0.80	2	1
Vitamin C (mg/d)	54.98	95.10	49.65	127.54	60.65	37.17	30.00	11	8
Vitamin D (µg/d)	2.09	0.67	2.14	0.74	2.05	0.59	0.00	–	–
Vitamin E (mg/d)	6.86	1.21	6.71 ^a	1.32	7.03 ^b	1.07	–	–	–

EAR, Estimated Average Requirement; %E, percentage of total energy intake.

^{a,b}Mean values within a row with unlike superscript letters were significantly different between boys and girls, as assessed by independent-samples *t* test ($P = 0.05$).

*For energy, the estimated energy requirement (EER) is given based on the children's sex, age, height, weight and activity level.

†Population guide for adults only.

‡UK Recommended Nutrient Intake in the absence of an EAR.

§As retinol equivalents.

||As niacin equivalents.

median (5th, 95th percentile) quantities of 56.25 (33.97, 98.74), 60.83 (0, 151.00) and 70.58 (0, 198.67) g/d, respectively. All children consumed vegetables, with a daily median (5th, 95th percentile) amount of 23.19 (9.42, 76.28) g/d. Noticeably, fatty fish and white meat, of which chicken was the major component, were consumed in similar quantities (median (5th, 95th percentile): 26.00 (0, 77.00) and 33.50 (0, 120.75) g/d) by a similar proportion of children (74% and 78%) and provided similar amounts of protein (8% and 9%), respectively. Cereal products and milk products contributed the largest amounts of energy, protein and nutrients to the diet, and the most commonly consumed cereal and milk products were white rice and cheddar cheese. These two food groups combined provided over 50% of Fe, Cu, Zn, iodine and folate intakes. Vegetables also provided at least 10% of Fe, Cu, vitamin B₆ and folate intakes. The median daily fatty fish consumption of 26.00 g/d provided 14% of Se intake and 10% of vitamin B₁₂ intake.

Discussion

The present study is the first report of dietary intakes of young children living in the Republic of Seychelles and shows that the diet of 5-year-old children within the SCDNS provides adequate amounts of Ca, Mg, Fe, Se, folate and vitamin B₁₂. These nutrients are recognised as important for growth and development in children^(1,31,32) and suggest that this group of children in Seychelles, unlike those in many other countries^(33–35), are not at risk of impaired cognitive development caused by Fe-deficiency anaemia. Furthermore, their diet provides sufficient intakes of folate and vitamin B₁₂, which are necessary to maintain neurological integrity⁽⁵⁾. An adequate Se intake may also have benefits for child development based on evidence that it can protect against possible neurotoxic effects of methylmercury to which all fish-eating populations are exposed⁽³⁶⁾. Given the children's frequent consumption of cereal products and milk products, fruits, vegetables and

Table 3 Consumption of food groups and mean percentage contribution to intakes of energy, protein and potentially important nutrients for cognitive development among 5-year-old Seychellois children (n 229), Seychelles Child Development Nutrition Study (SCDNS), 2006

	Intake of all consumers (g/d)		% contribution to the intake of										
	% of consumers	Median	P5, P95	Energy	Protein	Fe	Cu	Zn	Se	Iodine	Vitamin B ₆	Folate	
Cereal products	100	56.25	33.97, 98.74	35.59	25.04	32.42	51.37	32.06	44.44	22.98	23.88	30.41	
Milk products	93	60.83	0.00, 151.00	12.86	18.53	19.71	2.10	22.50	5.02	41.08	11.77	20.55	
Eggs	78	26.33	0.00, 60.13	2.25	5.12	5.47	2.81	4.88	5.14	14.41	3.29	5.94	
Vegetables	100	23.19	9.42, 76.28	5.59	6.88	10.70	10.57	7.11	4.33	3.68	15.97	15.87	
Fruit	95	70.58	0.00, 198.67	4.90	1.56	5.26	7.31	2.07	1.16	2.14	8.83	5.28	
Sugars, preserves & snacks	97	11.00	3.92, 26.69	7.55	1.91	2.39	4.51	1.82	0.99	0.84	2.53	2.36	
White fish	42	0.00	0.00, 46.50	0.51	3.04	0.51	0.17	0.54	2.88	1.25	1.47	0.23	
Fatty fish	74	26.00	0.00, 77.00	1.43	7.50	2.91	0.87	2.03	14.18	1.18	4.58	0.35	
Crustaceans	3	0.00	0.00, 0.00	0.02	0.07	0.04	0.13	0.08	0.16	0.08	0.02	0.01	
Molluscs	2	0.00	0.00, 0.00	0.08	0.28	0.12	0.16	0.13	0.63	0.11	0.24	0.02	
Fish products & dishes	43	0.00	0.00, 44.00	0.67	2.28	0.71	0.59	0.90	3.79	1.19	1.56	0.33	
Red meat	83	15.75	0.00, 62.75	2.49	7.67	2.61	2.27	8.21	4.56	1.50	6.72	1.22	
White meat	78	33.50	0.00, 120.75	2.92	8.92	2.39	3.45	5.64	4.36	1.81	2.76	0.82	
Meat products & dishes	80	24.50	0.00, 79.83	4.92	7.39	4.65	5.23	8.97	4.07	3.66	3.75	1.21	
Fats & oils	100	4.65	2.17, 10.11	7.97	0.10	0.67	0.47	0.03	0.12	0.82	0.61	0.83	
Beverages	100	125.36	45.66, 242.63	6.89	1.19	5.68	2.13	0.17	1.66	1.87	9.75	11.37	
Other foods*	89	128.77	66.01, 229.66	3.35	2.51	3.76	5.89	2.85	2.49	1.39	2.27	3.23	

P5, 5th percentile; P95, 95th percentile.

*Includes soups, sauces & miscellaneous, nuts & seeds, herbs & spices, custom foods.

fish, one might expect these children to meet the EAR for this range of micronutrients. Cereal products, including rice and fortified breakfast cereals, were the largest contributors to intakes of Fe, Se and folate in this cohort, as has been reported in other populations^(37,38). Milk products were the second largest contributing food group to nutrients, not surprisingly as milk imported to Seychelles is powdered and fortified with these micronutrients.

Reported energy intakes among ≥86% of boys and girls in this cohort were approximately 418 kJ/d (100 kcal/d) below the mean EER, suggesting that children were not eating enough to meet their energy requirements. These intakes are lower than energy intakes reported for children of a similar age living in European countries and the developing country of Papua New Guinea^(35,39). Bovet *et al.*⁽⁴⁰⁾ previously reported that underweight was common among Seychellois children, with approximately 20% of boys and girls attending public schools being classed as grade 1 thinness according to international standards⁽⁴¹⁾. Despite an overall rise in the prevalence of obesity and overweight in Seychelles⁽⁴²⁾, it is possible that underweight and associated low energy intakes are still an issue among young children. Subsequent follow-up of these children would be required to determine whether the low energy intakes reported by the present study compromise children's growth.

While many nutrients were found to be consumed in adequate amounts, at least 80% of children had sub-optimal intakes of Zn, vitamin A and niacin, and a further 23% of girls and 30% of boys were not meeting recommended intakes of vitamin B₆. Deficiency of vitamin A can affect visual development and growth⁽⁴³⁾, deficiency of niacin can affect psychological functions⁽³²⁾ and deficiency of Zn is associated with poor attention span and impaired motor development⁽⁴⁴⁾. For a large proportion of children reported Cu and iodine intakes were also below the RNI; however, in the absence of an EAR these low intakes cannot be interpreted as inadequacies⁽²⁵⁾, but neither should they be disregarded based on the essential role of iodine in neurodevelopment⁽⁹⁾. While it is likely that the low energy intakes detected in this cohort could account for these low nutrient intakes, it is also possible that the UK DRV are not appropriate standards with which to compare dietary intakes of Seychellois children. It was particularly unexpected that Seychellois children would have low intakes of the above nutrients in view of their average fish consumption of 42 g/d; an intake which is notably higher than the UK total fish intake of 20 g/d among 4–10-year-olds^(38,45). Fish is rich in many nutrients including iodine, Zn, Cu, vitamin A and *n*-3 long-chain PUFA⁽⁴⁶⁾. However, the intakes of several nutrients in the present study could have been underestimated as a result of incomplete nutrient composition data in the current nutritional database for all fish species consumed in Seychelles⁽¹⁷⁾. Indeed, for this same reason, it was not possible to investigate long-chain

PUFA intakes in the current study. This possible underestimation should also be taken into consideration when interpreting the low intakes of some nutrients found in the present study.

Several steps were taken in our study to reduce the limitations which can be associated with dietary assessment in children⁽⁴⁷⁾ and to strengthen the validity of the data presented, including the use of weighing scales to measure portion size and the statistical techniques used to detect dietary under-reporting and to remove intra-individual variability in nutrient intake. However, it was not possible to weigh all school meals consumed and although portion sizes for children were calculated and used in this instance, this approach may have impacted or affected the accuracy of dietary values obtained. The lack of specific DRV for the Seychelles may also be considered a potential limitation of the present study. As this cohort continues to be longitudinally assessed within the SCDNS, it would be of interest for future research to assess if these patterns of nutrient intake persist as children age and whether they are related to cognitive measures in these children.

Overall, the results of the present study indicate that this group of 5-year-old children in the Seychelles has adequate intakes of many nutrients deemed to be important for growth and cognitive development (protein, Ca, Mg, Fe, Se and B vitamins). Intakes of energy, Zn, vitamin A and niacin were found to be below this age group's requirements, but this may possibly reflect inaccuracies in our nutritional database. These findings on nutrient intakes of this group of children within the SCDNS should be valuable from a public health perspective with regard to implementing nutritional guidelines for children in the Seychelles population.

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