Public Health Nutrition: 11(1), 95–101 DOI: 10.1017/S1368980007000201

Vitamin A status in Cuban children aged 6–11 years

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Submitted 13 March 2006: Accepted 14 November 2006: First published online 3 July 2007

Abstract

Objective and setting: A nationwide study was performed in Cuba to assess vitamin A status and the intake of vitamin-A-providing foods in children aged 6–11 years.
Design and subjects: The sample comprised 1191 schoolchildren from first to sixth grade, both sexes, from municipalities randomly selected from the five eastern provinces of Cuba in 2002 (first semester) and from the four western and four central provinces in 2003 (first semester). A food-frequency questionnaire was completed by 2038 mother-and-child pairs.
Results: Mean (±standard deviation) plasma retinol concentrations were $1.77 \pm 0.48\,\mu mol\,l^{-1}$ in the western, $2.01 \pm 0.56\,\mu mol\,l^{-1}$ in the central and $1.40 \pm 0.41\,\mu mol\,l^{-1}$ in the eastern region. No child had plasma retinol concentration below $0.35\,\mu mol\,l^{-1}$, indicative of a high risk of clinical deficiency. Subclinical deficiency, plasma retinol concentration of $0.35–0.7\,\mu mol\,l^{-1}$, was seen in <2% of subjects in all three regions and was <5% even in the two provinces with the worst vitamin A status (Guantánamo, 4.6%; Las Tunas, 3.0%). Adequate status ($>1.05\,\mu mol\,l^{-1}$) was present in >90% of subjects in all western and central provinces, and in one of the eastern provinces (Holguín), whereas in the four remaining eastern provinces, adequate status was present in >75%. Only nine fruits and vegetables were consumed frequently (>3 times per week) by >50% of children. Thirty-seven per cent regularly consumed a supplement containing vitamin A.
Conclusions: Most Cuban children aged 6–11 years had adequate vitamin A status. Consumption of foods rich in vitamin and provitamin A, especially vegetables, was frequent but limited to a small variety of foods.

Keywords
Vitamin A
Retinol
Cuba
Children
Status
Food sources

Childhood is a period of relatively high requirement for vitamin A during rapid growth and development. The most vulnerable group for vitamin A deficiency (VAD) is pre-school children, whose body stores of vitamin A are low and for whom the common infections of the first years of life increase the vitamin requirement[1,2]. School-age children also have increased vitamin A requirements for growth and are theoretically at risk of VAD, and recent studies have suggested that VAD is indeed a public health problem in children of this age group[3].

In the final decade of the 20th century, policy-makers and health authorities, together with non-governmental organisations such as UNICEF (United Nations Children's Fund), tried to eliminate childhood VAD and blindness[1,2,4,5]. Following the International Conference on Nutrition in Rome in 1992, it was agreed to establish global, regional and national Plans of Action for Nutrition including vitamin A. These plans recommended development of food and health-based strategies to control and prevent several micronutrient deficiencies. Supplementation was the main short-term strategy, and was linked to National Immunisation Days in many countries. Other strategies employed were food fortification and quality improvement, and health improvement measures.

The reports of the Cuban National Food and Nutrition Surveillance System between 1992 and 1995 showed that a high percentage of Cuban children had vitamin A intakes lower than 70% of the recommended daily allowance[6]. A study of Cuban children aged 7–11 years from representative sites in 1993[7] found that 5% had serum retinol values $<0.35\,\mu mol\,l^{-1}$ and 45.7% had values between 0.35 and $1.05\,\mu mol\,l^{-1}$.

A remedial strategy was therefore introduced by the Cuban Ministry of Public Health in 1993 comprising a National Plan of Action for Nutrition which provided country-wide supplementation with 'Multivit', a national multivitamin supplement containing 2500 IU (833 μg) vitamin A daily. Another public health strategy that was introduced before was to offer a daily litre of milk at a subsidised price for children aged <7 years. Both

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strategies have continued during the past 10 years and are still in place.

The objective of the present study was to evaluate the vitamin A status of a representative sample of Cuban children aged 6–11 years, in primary education in 2002–2003, so as to assess the efficacy of these public health measures. The World Health Oganization (WHO) recommends the use of plasma retinol as the main biological indicator of subclinical VAD, supported by certain ecological indicators: (1) nutritional and diet-related indicators (breast-feeding pattern, low birth weight, food availability, consumption of vitamin-A-rich foods); and (2) illness-related indicators (i.e. immunisation coverage, diarrhoeal disease rate, etc.). For this age group, we decided to use plasma vitamin A together with the consumption of vitamin-A-rich foods and food availability. The food-frequency questionnaire (FFQ) that we used was based on the Helen Keller International Food Frequency Method, designed to assess community risk of VAD.

Materials and methods

Sample design

A cross-sectional nationwide study was carried out during the first semester of 2002 in five provinces of the eastern region of Cuba (Las Tunas, Holguín, Granma, Santiago de Cuba and Guantánamo). During the first semester of 2003, this study was continued in the western region (provinces of Pinar del Rio, Ciudad de la Habana, La Habana and Matanzas) and in the central region (provinces of Villa Clara, Cienfuegos, Sancti Spiritus, Ciego de Avila and Camagüey). The population studied comprised schoolchildren aged 6–11 years, from first to sixth grade, including both those who received lunch at home ('external meal provision') and those who received lunch at school ('semi-internal meal provision'). It included only residents of urban areas: specifically, the chief town of each municipality. Data for such a sample represents the majority of the Cuban population because 75% of Cuba's population is urban.

In each province, 175 children were selected; this sample being sufficient to estimate the prevalence of VAD in each region with an absolute error of 5%, a confidence level of 95% and a design effect (the measure of the relationship between individuals living in the same cluster) of approximately 1.5. There are no previous studies which can define an exact value of the design effect, but minimal regional differences in nutritional status, food intake and health care suggest that clustering has little influence in Cuba, and the chosen value of 1.5 reflects this assumption. One province, Ciego de Avila, was excluded from the study due to failure to complete the fieldwork. The final participating sample was $n = 2275$, whose categories (age, sex and supplementation category) were subject to some to missing data. The overall response rate was 90% of the selected sample.

For selection of the population sample, a combination of sampling strategies was used. The population units were selected by random sampling from stratified clusters. From each population unit, individuals were then selected by quota sampling.

Each of the three regions (as the primary division or stratum) was divided into secondary strata (provinces). In each province the municipalities were considered as clusters, which were selected with a probability proportional to the size of their school populations aged 6–11 years.

In the provinces Ciudad de la Habana and La Habana, 30–40% of the municipalities were selected. In the other provinces, the main municipality was selected, plus 30–40% of the remainder. Within the municipalities, individual schools were selected by a systematic random sampling process, with sub-stratification for neighbourhoods so as to guarantee representative geographical dispersion of the schools sampled. Within each school, the children were selected randomly to achieve quotas of not more than two children in each grade, one of each sex, and were randomised by the method of provision of lunch. With this sampling strategy we obtained a random sample of children with national coverage and thus obtained vitamin A status by age (i.e. grade), gender and according to the method of lunch provision.

Before the fieldwork, training workshops were held in order to train the teams of fieldworkers. Written consent was obtained from one of the parents of each of the selected children, together with verbal assent from the children themselves. The study was approved by the Ethical Committee of the Institute of Nutrition and Food Hygiene (INHA).

Blood sampling and retinol determination

For plasma retinol, a 50–60% sub-sample of all the plasma samples was analysed. The selection of this sub-sample was made in the same way as that of the main sample in order to achieve the required stratification with respect to municipality, age and sex.

A blood sample was drawn from the antecubital vein of the children into a tube containing ethylenediaminetetraacetic acid as anticoagulant and was kept cold and protected from light. During the next 4 h plasma was separated and kept frozen at –20°C for up to 1 week, and then transported to INHA where it was kept at −80°C until the retinol analysis was carried out. Plasma retinol was measured by high-performance liquid chromatography (HPLC)[8]. Quality control for accuracy was achieved by sample exchange and by blinded assay of 30 plasma samples at both INHA and the Institute of Nutrition Potsdam, Germany. The mean retinol result agreed to within 0.7% between the two laboratories, with a two standard deviations range of 87.4–114.0%. Within-assay precision for duplicates was 4.6% (coefficient of variation).

Dietary intake

Several WHO VAD indicators[9] address the risk of suboptimal intakes of vitamin A and its precursors. Dietary intake of vitamin A and its precursors was evaluated in the present study by a qualitative FFQ completed by the mother, with the child's participation. Consumption of foods rich in retinol or carotenoids during the six months previous to the study was explored. The market availability of vegetables in each province during the first semester of both years was assessed.

From the eastern region, 830 questionnaires were analysed; 682 from the central region and 526 from the western region, providing a total of 2038. The questionnaires from Guantánamo were excluded because of incorrect administration. The questionnaires listed 11 animal foods and 27 vegetable foods. The answers were classified into three categories: frequent (>3 times per week), less frequent (<3 times per week) and never if never consumed during 6 months. Mango, although out of season at the time of the study, was included because of its high content of provitamin A carotenoids and its frequent use by children. Liver, having a very high content of preformed vitamin A, was classified as being frequently consumed if it was eaten at least once per month. The frequency of use of all dietary supplements containing vitamin A was also requested.

Statistical analysis

The results from the biochemical indicator, plasma retinol, were represented by the arithmetic mean, standard deviation, minimum and maximum values. They were also described by the prevalence of subclinical deficiency (0.35 to $<0.70\,\mu\text{mol}\,l^{-1}$) and of suboptimal values (0.70 to $<1.05\,\mu\text{mol}\,l^{-1}$).

In order to compare means, Student's *t*-test was used for two independent groups and analysis of variance (ANOVA) was used for multiple groups. The database was created in Microsoft® Excel. Data analysis was by SPSS version 10.0 (SPSS Inc.).

Results

The plasma retinol concentrations from the three regions (eastern, central and western) of the country are shown in Tables 1 and 2. No child had a value below $0.35\,\mu\text{mol}\,l^{-1}$ ($10\,\mu\text{g}\,\text{dl}^{-1}$).

There was a significant difference ($P<0.001$) in mean plasma retinol concentrations between central and western regions. There were also significant differences ($P<0.001$) between the eastern region and the western and central regions (by ANOVA). The highest values for mean plasma retinol were found in the central region and the lowest in the eastern region. The highest prevalence of subclinical deficiency ($<0.70\,\mu\text{mol}\,l^{-1}$) was encountered in four of the provinces of the eastern region: Guantánamo (4.6%), Las Tunas (3.0%), Granma (1.5%) and Santiago de Cuba (0.6%), and in one province of the central region (Camagüey, 2.2%). In the eight remaining provinces no values $<0.70\,\mu\text{mol}\,l^{-1}$ were encountered.

The prevalence of retinol values between 0.70 and $1.05\,\mu\text{mol}\,l^{-1}$ ranged from 16 to 21% in the provinces of the eastern region with a mean of 17.3% (except Holguín which had 7%). The central and western regions presented fewer suboptimal values: mean of 2.8 and 4.1%, respectively. The prevalence of optimal retinol values ($>1.05\,\mu\text{mol}\,l^{-1}$) was >90% in all the provinces of the eastern and central regions and in Holguín, whereas in the four remaining western provinces it was >75%.

There were no significant relationships of retinol with sex or age, although there was a trend towards an increase with age in males ($P=0.073$ by linear regression) (Table 3).

The estimation of vitamin A intake by the FFQ showed that only nine of 38 foods that are considered good sources of vitamin A or its precursors were consumed frequently by 50% or more of the children in each province (Figs 1 and 2).

Of the animal foods, milk (or yoghurt) was consumed frequently, i.e. by more than 60% of the children. Eggs were consumed frequently by more than 60% of the children except by those from the eastern region. Liver was consumed frequently by a high proportion of the

Table 1 Plasma retinol concentrations in children aged 6–11 years in the eastern region of Cuba in 2002

Province	n	Mean ± SD	Range	Prevalence (%)	
				0.35 to $<0.70\,\mu\text{mol}\,l^{-1}$*	0.70 to $<1.05\,\mu\text{mol}\,l^{-1}$†
Las Tunas	100	1.34 ± 0.38	0.38–2.48	3.0	21.0
Holguín	88	1.69 ± 0.51	0.88–3.20	0	7.1
Granma	88	1.50 ± 0.47	0.43–2.62	1.5	16.1
Santiago de Cuba	100	1.34 ± 0.34	0.40–2.62	0.6	17.4
Guantánamo	87	1.35 ± 0.37	0.57–2.35	4.6	17.2
Total	463	1.40 ± 0.41	0.38–3.20	2.0	17.3

SD – standard deviation.
* A population prevalence of less than 5% of deficient values $<0.7\,\mu\text{mol}\,l^{-1}$ is evidence of adequate vitamin A status.
† Values between 0.7 and $1.05\,\mu\text{mol}\,l^{-1}$ are considered suboptimal but not deficient.

https://doi.org/10.1017/S1368980007000201 Published online by Cambridge University Press

Table 2 Plasma retinol concentrations in children aged 6–11 years in the central and western regions of Cuba in 2003

Region/province	n	Mean ± SD	Range	Prevalence (%) 0.35 to <0.70 µmol l^{-1}*	Prevalence (%) 0.70 to <1.05 µmol l^{-1}†
Western region					
Pinar del Río	91	1.82 ± 0.49	0.71–3.13	0	5.5
La Habana	91	1.71 ± 0.37	1.01–2.47	0	2.2
Ciudad de la Habana	92	1.84 ± 0.57	0.78–4.31	0	5.6
Matanzas	90	1.73 ± 0.45	0.85–3.56	0	3.3
Total	364	1.77 ± 0.48	0.71–4.31	0	4.1
Central region					
Villa Clara	92	2.18 ± 0.59	0.85–4.23	0	3.4
Cienfuegos	91	1.90 ± 0.45	0.74–3.30	0	1.1
Sancti Spiritus	92	2.03 ± 0.52	1.02–3.40	0	1.1
Camagüey	89	1.95 ± 0.62	0.68–4.14	2.2	5.6
Total	364	2.01 ± 0.56‡	0.68–4.23	0.6	2.8

SD – standard deviation.
*A population prevalence of less than 5% of deficient values <0.7 µmol l^{-1} is evidence of adequate vitamin A status.
† Values between 0.7 and 1.05 µmol l^{-1} are considered suboptimal but not deficient.
‡ $P < 0.001$ by Student's *t*-test between the central and western regions.

Table 3 Plasma retinol concentrations in children (all regions) by sex and age

	Western and central regions n	Western and central regions Mean ± SD	Eastern region n	Eastern region Mean ± SD
Age (years)				
6	115	1.85 ± 0.49	65	1.34 ± 0.44
7	125	1.89 ± 0.52	82	1.39 ± 0.43
8	109	1.87 ± 0.53	91	1.36 ± 0.36
9	123	1.84 ± 0.48	74	1.44 ± 0.38
10	126	1.95 ± 0.54	89	1.43 ± 0.35
11	116	1.94 ± 0.62	62	1.46 ± 0.47
Sex				
Male	358	1.88 ± 0.53	236	1.37 ± 0.41
Female	356	1.90 ± 0.53	227	1.44 ± 0.42

Neither the overall linear regression of plasma retinol against age nor the retinol difference between the two sexes was significant at $P < 0.05$.

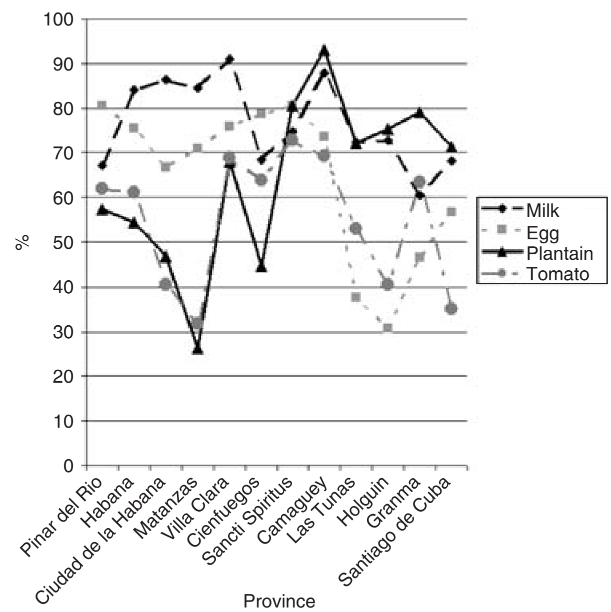

Fig. 1 Percentage of children aged 6–11 years who frequently (at least 3 times per week) ate four specific foods that are rich in vitamin A or provitamin A

interviewed children only in Santiago de Cuba (59.5%) and Las Tunas (50.7%).

Among carotenoid-containing vegetables, bananas and plantains were widely consumed and were available in the markets all year long. Tomatoes, mandarins, oranges, mangos and guavas were also widely available for part of the season of the study (December to June) – mandarins were available for 2 months; oranges for 3–4 months; tomatoes for 5–6 months; mangos were available from May until August, thus overlapping by 2 months with the fieldwork. It can be seen from Fig. 1 that the central region had the highest intake of vitamin-A-providing foods, and it also had the highest plasma retinol concentrations (Tables 1 and 2).

Unexpectedly, vegetables such as dark green leafy vegetables, carrot, red and green pepper were consumed less than once in 6 months by >85% of the children. Pumpkin and papaya (which have generous amounts of provitamin A carotenoids) were eaten only infrequently.

Of 1347 children, 36.6% took supplements containing vitamin A during the six months before the survey. Of these, 96% took a daily tablet of 'Multivit' – the national multivitamin supplement containing 2500 IU (833 µg) vitamin A. There was no significant difference ($P = 0.21$) in plasma retinol concentration between the children who used dietary supplements and those who did not.

Discussion

In spite of major efforts worldwide to eliminate VAD, at the beginning of the 21st century it is still a public health problem in many countries. Low vitamin A status may be

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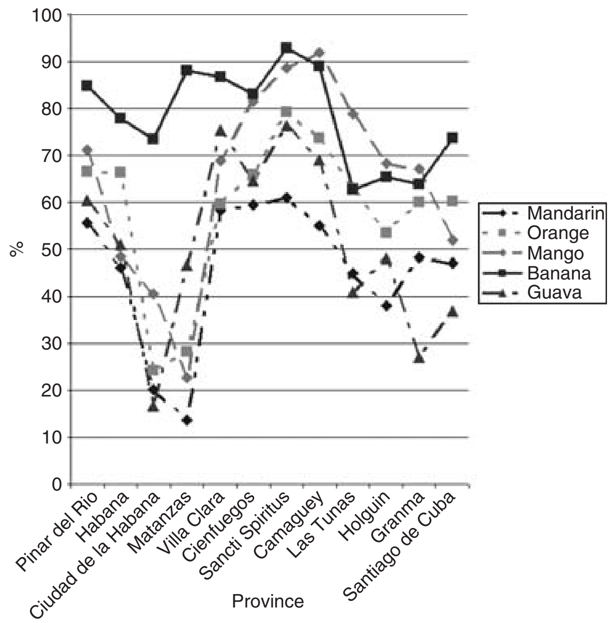

Fig. 2 Percentage of children aged 6–11 years who frequently (at least 3 times per week) ate selected foods (five specific fruits) that are rich in provitamin A

responsible for impaired iron mobilisation, anaemia, disturbed cellular differentiation, depressed immune response, increased morbidity and mortality, growth retardation and xerophthalmia[3,4,10].

Of all the regions of the world, Southeast Asia is most affected by clinical and subclinical VAD. Singh and West[11] estimated a VAD prevalence there of 23% in schoolchildren aged 5–15 years. This represents 83 million children, 11% of whom had at least moderate functional deficiency (night blindness or Bitot's spots).

Among the developing countries, Latin America and the Caribbean are less severely affected, and VAD here is mostly subclinical. A WHO report in 1995[1] estimated a regional subclinical VAD prevalence of 20%. Three years later, Mora *et al.*[12] reported 25% prevalence (14.6 million children aged <5 years). Subclinical VAD was highly prevalent in five of the surveyed countries, moderate in six and mild in five. The main contributors to high subclinical VAD prevalence were Brazil, Mexico and Peru.

The two main strategies used to control VAD in the South American region have been supplementation and food fortification. Some countries choose to supplement children <5 years of age, linked to immunisation campaigns targeting key infectious diseases. Sugar fortification was proved to be an efficient measure to elevate plasma retinol levels. Reduction of subclinical VAD prevalence, from 26% in 1988 to 16% in 1995, was achieved in Guatemala and from 40% in 1966 to 14% in 1996 in Honduras[12]. In Venezuela, corn flour was fortified with vitamin A and other micronutrients, and by 2003 it was concluded that VAD was no longer a health problem in urban, rural or indigenous Venezuelan children[13].

It is widely accepted that a population prevalence of <5% of retinol values <0.70 μmol l^{-1} indicates adequate vitamin A status[9] and that retinol levels are generally >1.05 μmol l^{-1} in well-nourished populations[4,9,14]. Studies of vitamin A status in the Caribbean region have been targeted mainly towards pre-school children, so that less information is available about schoolchildren. The English-speaking Caribbean countries have reported that no significant evidence of VAD exists there in schoolchildren. The prevalence of serum retinol values <25 μmol l^{-1} (0.88 μmol l^{-1}) was 1.2% in Dominica, and 1.1% in St. Vincent and the Grenadines[12]. In a recent nationwide study carried out in Mexican children under 12 years of age, 25% of children below 8 years old had subclinical VAD; among children aged 9–10 years it was 12.5%, and among those aged 11–12 years it was 9.7%[15]. In another study of children aged 6–18 years from Medellín, Colombia[16], only 3.6% of the population had plasma retinol values between 0.35 and 0.70 μmol l^{-1}, whereas 10.3% of values were between 0.70 and 1.05 μmol l^{-1}. Mean plasma retinol values in Colombian children (males, 1.27 μmol l^{-1}; females, 1.32 μmol l^{-1}) were lower than in Cuban children, and those in Mexican children (0.85 μmol l^{-1}, both sexes combined) were much lower.

While the present study found no plasma retinol values <0.70 μmol l^{-1} in the province of Ciudad de la Habana (Havana city), by contrast in a group of schoolchildren ($n = 110$) from the same province studied in 1996 (Dr Manuel Hernandez, unpublished data), the prevalence of subclinical values was 10.9%. The prevalence of optimal plasma retinol values (>1.05 μmol l^{-1}) increased from 67.6% in 1996 to 94.4% in the present study, suggesting an improvement in vitamin A status over this 6- to 7-year period.

In the present study, the mean values of plasma retinol are within the normal range by comparison with published reference values[14] from 544 well-nourished children aged 2–6 years (95% confidence interval percentiles, 1.02–2.90 μmol l^{-1}).

Mean plasma retinol concentrations were higher in schoolchildren in the present study than in pre-school children[17], both in the western region (1.77 vs. 1.49 μmol l^{-1}) and in the central region (2.01 vs. 1.57 μmol l^{-1}). In the present study, fieldwork in the eastern region was carried out the year before that in the central and western regions; therefore the regional comparison of results requires some caution. However, the fact that plasma vitamin A concentrations in the eastern region were also lower than in pre-school children[17] (1.40 vs. 1.47 μmol l^{-1}) supports the parallel conclusion from the present study. For both age groups, children in the central region had the best vitamin A status and children in the eastern region the worst.

https://doi.org/10.1017/S1368980007000201 Published online by Cambridge University Press

The two key strategies that dominated the Cuban National Plan of Action for Nutrition[18] focused on the improvement of vitamin A status by supplementation and by food diversification to include more vitamin-A-providing foods, particularly in the population from 6 to 11 years of age.

The percentage of children who used vitamin A supplements in the present study was similar to that observed in a group of children aged 5–12 years in a national survey carried out in 1998, which included 15 000 families from both urban and rural areas (34.5% of whom were taking supplements)[19]. The effect of vitamin A supplementation over 10 years can actually be considered higher than the results offered by these cross-sectional assessments. The reason for such a discrepancy might be connected to the fact that people (in these case children) supplement themselves irregularly. The impact of promotional campaigns might have produced oscillations in consumption patterns. Moreover, the availability of pills at pharmacies all over the country might be responsible for some changes.

Food diversification, focusing on increased intakes of vitamin-A-providing foods, is a strategy to reduce micronutrient deficiencies, and to achieve a balanced and healthy diet[20]. In Cuba, dietary diversity has increased over the last 10 years, through an increase in vegetable and liver availability. The continuing improvement of availability of these foods during this period seems to account for the parallel improvement in vitamin A status. According to Food Balance Sheets issued by the Food and Agriculture Organization of the United Nations in its annual reports, consumption of fruit and vegetables in Cuba increased considerably between 1993 and 2003. Fruit consumption increased from 92.77 kg $person^{-1}$ $year^{-1}$ in 1993 to 141.32 kg $person^{-1} year^{-1}$ in 2003, while vegetable consumption rose from 42.29 to 154.83 kg $person^{-1} year^{-1}$ over the same period[21].

However, intakes of vegetables are still limited by factors such as limited accessibility and poor education. The present result shows that vegetable consumption is confined to a restricted range of foods, as was found in previous studies[17,22,23]. Food education programmes need to be improved in the Cuban population, especially for young people.

Acknowledgements

Sources of interest: The study was supported financially by UNICEF.

Conflict of interest declaration: None.

Authorship responsibilities: All four authors participated in the conception and design of the study. Moreover, C.M.-M. was responsible for vitamin A analysis and its quality control, analysis and interpretation of biochemical and dietary data, and final writing of the article; G.P.-R. contributed to blood sample collection, plasma retinol analysis by HPLC, and drafting the article; P.M.-G. contributed to sample size calculation, statistical analysis, and revising the article; J.R.-P. contributed to the dietary data base, analysis and interpretation.

Acknowledgments: We are grateful to Humberto Márquez (Pinar del Rio), Belkis Gámez (La Habana), Maria del Carmen Valiente and Andris Chiang (Ciudad de la Habana), José Luis Doblado (Matanzas), Irene González (Villa Clara), Estrella Martín (Sancti Spiritus), Juan Chaviano (Cienfuegos), Sara Orozco (Camagüey), Elsy González (Las Tunas), Lisset Selva (Holguín), Regla O'Farrill (Granma), Karelia Paulí (Santiago de Cuba) and Roxana Herrera (Guantánamo), and their staff in each province, for their valuable assistance in coordinating the fieldwork, collecting and preparing blood samples, and conducting the dietary surveys. We thank Elsa Alonso, Yeniset Viñas and Dania Herrera for laboratory analysis and for preparing databases. We also thank Maria Antonia Torres and Ruth Garcia from the Health Department of the Ministry of Education, and their colleagues in the provinces, for the organisation of the study. Chris Bates provided advice about interpretation and English idiom. All persons acknowledged in the paper gave their approval to be acknowledged.

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https://doi.org/10.1017/S1368980007000201 Published online by Cambridge University Press