

Low prevalence of inadequate micronutrient intake in young children in the south of Brazil: a new perspective

Caroline Nicola Sangalli¹, Fernanda Rauber² and Márcia Regina Vitolo^{3*}

¹Graduate Program in Health Sciences, Universidade Federal de Ciências da Saúde de Porto Alegre, 245 Sarmiento Leite, Porto Alegre, 90050-170, Brazil

²Nutrition Research Group (NUPEN), Universidade Federal de Ciências da Saúde de Porto Alegre, 245 Sarmiento Leite, Porto Alegre, 90050-170, Brazil

³Department of Nutrition, Universidade Federal de Ciências da Saúde de Porto Alegre, 245 Sarmiento Leite, Porto Alegre, 90050-170, Brazil

(Submitted 8 December 2015 – Final revision received 19 June 2016 – Accepted 21 June 2016 – First published online 25 July 2016)

Abstract

In Brazil, children's eating patterns have been characterised by an increased consumption of ultra-processed foods that are fortified. Our aims were to (1) estimate the prevalence of inadequate micronutrient intake among children from low-income families and (2) to assess micronutrient intake from fortified foods. We carried out a cross-sectional study from a randomised field trial conducted at healthcare centres in Porto Alegre, Brazil, with 446 mother–child pairs, with the children aged 2–3 years. Dietary data were assessed using two 24-h recalls. The prevalence of inadequacy for six micronutrients was estimated using the proportion of individuals with intakes below the estimated average requirement (EAR). Micronutrient intakes from fortified foods were evaluated using EAR and upper tolerable level (UL). Healthy foods consumption was below the recommendations, except for beans, and 88.1% of the children consumed ultra-processed foods. A low prevalence of inadequate micronutrient intake was observed for Fe (1.2%), vitamin C (4.7%), vitamin A (5.2%), Ca (11.4%) and folate (15.2%). None of the children had intakes less than the EAR for Zn. Fortified foods contributed between 11.3 and 38.3% to micronutrient intakes, and 43.0% of the children met the EAR for Fe, 13.9% for vitamin C and 12.3% for Zn using fortified foods only. In addition, 4.0% of the children exceeded the UL for vitamin A, 3.1% for Zn, 1.1% for folic acid and 0.2% for Fe. These results highlight a low prevalence of inadequate micronutrient intakes among children and suggest that such a group could be at risk of excessive micronutrient intakes provided by ultra-processed foods.

Key words: Requirements: Preschool children: Micronutrient intake: Nutrition

Vitamin and mineral intakes among young children have been investigated because of their importance in various metabolic and physiological processes during childhood⁽¹⁾, as well as because they are an important part of optimal nutrition at preschool age⁽²⁾. Vitamin A, vitamin C, folate, Ca, Fe and Zn deficiencies may result in growth stunting^(3–5), increased morbidity^(6,7) and delayed cognitive function^(8–10).

Changes in children's dietary patterns in the last decade (especially lower fruit and vegetable consumption) are predictive of inadequate micronutrient intake^(11–14). The literature describes an increased consumption of ultra-processed foods (industrial formulations manufactured from substances derived from foods or synthesised from other organic sources⁽¹⁵⁾ around the world)^(16–18), especially fortified foods (to which nutrients have been added), which have been associated with a decrease in the prevalence of inadequate vitamin and mineral intakes^(19–21).

In Brazil, thus far, there has been no national population survey that has investigated the percentage of young children below the estimated average requirement (EAR). The only study that estimated the prevalence of inadequate micronutrients intake was a multicentre study including children aged 2–6 years (*n* 3058) who were enrolled in kindergartens that offered all meals during the day. Such data suggest low prevalence of inadequate intake for folate (<0.001%), Ca (12.6%), vitamin A (0.7%), vitamin C (<0.001%), Fe (0.4%) and Zn (<0.001%)⁽²²⁾. Furthermore, no publications were found describing a prevalence of inadequate micronutrient intake and the contribution of fortified food for children at 2–3 years of age in Brazil, especially in low-income families, as they often consume poor-quality diets and are supposedly at risk for inadequate micronutrient intake^(23–25). Therefore, the present study aimed to (1) estimate the prevalence of inadequate

Abbreviations: EAR, estimated average requirement; UL, upper tolerable level.

* **Corresponding author:** M. R. Vitolo, email marciavitolo@hotmail.com

micronutrient intake patterns among children from low-income families and (2) to assess micronutrient intake from fortified foods.

Methods

Study design

This study used data of children who participated in a randomised field trial with intervention in healthcare workers on breast-feeding and dietary practices⁽²⁶⁾. The randomisation units were healthcare centres that provide primary medical services predominantly to low-income residents. The outcomes were assessed for mothers and children who received treatment at these centres. From April to December 2008, all pregnant women at the participating healthcare centres were invited to sign up for outcome tracking by fieldworkers who were blinded to the allocation status of the participants. The births occurred between May 2008 and February 2009.

The sample size initially chosen for the trial was based on the goal of detecting a difference in the prevalence of exclusive breast-feeding at 4 months⁽²⁷⁾. A power of 90%, CI of 95%, loss prediction of 20% and design effect of 1.5 were used to calculate the sample size, resulting in the inclusion of 300 mother–baby pairs in the intervention group and another 300 in the control group. Recruitment of 720 individuals was estimated in order to reach the sample size, accounting for an anticipated loss of 20%. Of the 715 pregnant women who registered initially, 635 of their children were enrolled to the study at 6–9 months of age. At 2–3 years of age, 476 children remained for the follow-up study (Fig. 1). As the present study had a different aim, we calculated that the available sample at 2–3 years of age was sufficient to investigate the prevalence of inadequate micronutrient intake. The estimated prevalence of inadequate nutrient intake was set at 65%, with a margin of error of 5% and a 95% CI⁽²²⁾.

This study was approved by the Ethics Committee of the Federal University of Health Sciences in Porto Alegre and the Ethics Committee of the Porto Alegre municipal government and was registered on the ClinicalTrials.gov website under the identification number NCT00635453. A consent form with all of the study's information was given to the responsible parties, clarified and signed.

Data collection

Trained fieldworkers, masked to allocation status, contacted participants at baseline and approximately 6 months and 3 years after birth. Data on sex and date of birth were collected from the children's vaccination records, and the mothers were asked about their race, age at child's birth, maternal education level, maternal employment and annual family income during home visits conducted in 2009. When the children were 2–3 years old (2011–2012), trained fieldworkers performed dietary recalls during home visits, asked about Fe supplement use and collected anthropometric data using a digital scale (Techline) to the nearest 0.1 kg and a stadiometer (SECA) to the nearest 0.1 cm. BMI-for-age z-scores were estimated on the basis of World Health Organization standards⁽²⁸⁾.

Nutrient intakes and nutrient sources from foods

In this study, two 24-h dietary recalls were collected for each child on two non-consecutive days chosen randomly during a period of 2 weeks to 1 month during home visits. Mothers provided information about all foods consumed by their children during the previous 24 h. Details about food types, amounts and preparation methods were recorded. Common household measures (e.g. teaspoons, tablespoons, cups and serving sizes) were used to help mothers report the amounts of food given to their children. Vitamin A ($\mu\text{g}/\text{d}$), vitamin C (mg/d), folate ($\mu\text{g}/\text{d}$), Ca (mg/d), Zn (mg/d) and Fe (mg/d) intake estimates were obtained using Dietwin[®] software program (version 2008 professional; Dietwin[®]), which is based on US Department of Agriculture chemical composition tables (USDA, Agricultural Research Service, 1998) to assess nutrient intakes. Manufacturers' information on industrial products and other available national chemical composition tables were added to the programme^(29,30).

Data on the consumption (in grams or millilitres per day) of healthy foods and fortified foods were obtained to identify the children's dietary micronutrient sources. Fruits, vegetables, beans, meats (beef, chicken, pork, poultry, fish) and dairy products (milk and yogurt) were considered healthy foods and contributed to >30% of micronutrient intake. Therefore, they were considered the 'main food sources of micronutrients'⁽³¹⁾. Ultra-processed foods that were fortified (gelatin desserts, ready-to-eat cereal, soya juice, soya milk, powdered milk, powdered chocolate, baby cereal and *petit suisse* cheese) were included because of their high consumption prevalence in this sample of children ($\geq 20\%$).

According to official guidelines, the amounts of healthy foods were investigated as servings per day and compared with the recommendations for fruits (240 g), vegetables (180 g), beans (25 g), meats (70 g) and dairy products (600 ml)^(26,32,33). Consumption of natural fruit juices was not considered to calculate total fruit intake. Potatoes were not considered components of the vegetable group, as they are traditionally included in the carbohydrate-rich food group, in accordance with Brazilian food guides^(26,32).

Data analysis

The multiple source method (MSM) was used to estimate the means and distribution percentiles for usual dietary micronutrient intake and food group consumption. The MSM calculates the dietary consumption of individuals using logistical regression and distributes the individual data adjusted for the population^(34,35). All participants were considered consumers of micronutrients. For the food and beverage groups, a probability value of 0.5 (50%) was used to assign the status of habitual consumer, assuming that there was a percentage (50%) of habitual consumers among the preschool children who did not consume such foods or beverages in at least one of the dietary surveys. Estimated intakes were calculated for those who were chosen in this manner. The presence of outliers was investigated using box-plot graphs.

The prevalence of inadequate intake for each micronutrient was estimated using the proportion of individuals below the



EAR, which represents the median nutrient requirement. The RDA, which represents a value that meets the needs of approximately 98% of health people, was used as complementary reference to verify how many children were above the values^(36–40). The contributions of fortified foods to vitamin A, vitamin C, folate, Ca, Zn and Fe intakes were calculated using the amount each child consumed individually. The contributions of fortified foods were analysed according to the EAR and upper tolerable level (UL). UL is the highest daily intake of a nutrient considered to be safe, above which potential adverse health effects can occur. It is defined as the absolute value of usual micronutrients obtained from fortified food items and supplements^(36–40).

The database was built using Statistical Package for the Social Science, version 16.0 (SPSS Inc.), and all statistical analyses were performed using the same software. All data were double entered independently by different people for subsequent validation in EPI-INFO, version 6.4 (CDC). The Kolmogorov–Smirnov test was used to assess distribution normality. Variables were described using means and standard deviations, medians and minimum and maximum values and per cent frequency. Statistical significance was set at $P < 0.05$.

Comparisons of maternal and family characteristics between children who were lost to follow-up and those who remained in the study were made using the χ^2 test and Student's *t* test, or the Mann–Whitney *U* test, as deemed appropriate. To eliminate the potential effect of energy intake, we compared the mean daily energy intake between children whose intakes were above the EAR and those who met EAR for each micronutrient using the Mann–Whitney *U* test. Moreover, comparisons in terms of the prevalence of inadequate intake for each micronutrient between the intervention and control groups were made using the χ^2 test.

Results

Of the 715 pregnant women who registered initially, 635 of their children were enrolled into the study at 6–9 months of age (an 11.1% loss). The data collected at 2–3 years of age were obtained from the 6–9-month sample, and 476 children remained in the follow-up (a 24.8% loss). The causes for loss were refusal to participate in the study (n 32), death of the child or mother (n 1), re-location to another city (n 56) and inability to locate the family (n 70) (Fig. 1). Of these 476 children, thirteen were excluded from the analyses because of the presence of genetic diseases and seventeen were excluded because they did not have complete dietary data. Thus, the data of 446 preschool children were analysed for this study. No differences were found for race, sex, weight, length, maternal age at child's birth, maternal education level, maternal employment and family income between the children who were lost to follow-up and those who remained at 2–3 years of age ($P > 0.05$; data not show).

Regarding maternal and family characteristics, 18.4% (n 82) of the mothers were under 20 years of age at the child's birth, 46.4% (n 207) had 8 years of schooling or less and 65.7% (n 293) did not have paid employment. Family income was

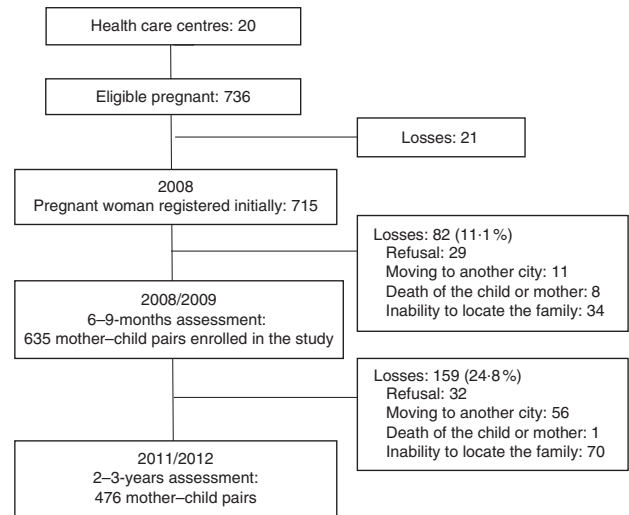


Fig. 1. Flow diagram of the study.

low for most families – 79.6% (n 344) had a monthly income less than three times the national minimum wage (approximately US\$ 565.00/month).

More than half of the children were male (51.5%, n 238) and 35.3% (n 162) were non-white. The prevalence of overweight was 43.1% (n 196), and the mean daily energy intake was 6289 (SD 1347) kJ 1503 (SD 322) kcal, which is higher than the requirement for this age (4874 kJ (1165 kcal)). Fe supplement use was recorded for 2.4% (n 11) of the children. No difference was found for the micronutrients assessed (vitamin A, vitamin C, folate, Ca, Zn and Fe) and energy intake, neither for intervention nor control groups ($P > 0.05$; data not show).

The mean values of vitamin A, vitamin C, folate, Ca, Zn and Fe intakes were higher than the requirement, as shown in Table 1. A low prevalence of inadequate micronutrient intake was observed for all micronutrients studied, especially Zn, whose intake was above the EAR (Table 1 and Fig. 2). Furthermore, 99.8% (n 445) of the children presented a consumption above the RDA value for Zn, 92.4% (n 412) for vitamin C, 78.7% (n 351) for vitamin A, 71.3% (n 318) for Ca, 70.2% (n 313) for folate and 67.9% (n 303) for Fe (Fig. 2).

Consumption of healthy foods and recommended servings per day, considering the mean consumption obtained by two 24-h recalls, are described in Table 2. Mean numbers of servings per day were below the minimum recommendations for healthy foods, except for beans (80.5%). The proportions of children who consumed recommended servings of meats, dairy products and fruits were 35.4% (n 158), 28.3% (n 126) and 2.5% (n 11), respectively. None of the children met the recommendations for vegetables.

The prevalence of children who consumed fortified foods was 88.1% (n 393). The percentage of micronutrient intake provided by consuming ultra-processed foods was 38.3 (SD 33.5) for Fe, 20.4 (SD 28.3) for vitamin A, 19.7 (SD 11.8) for Ca, 17.2 (SD 31.4) for vitamin C, 14.6 (SD 19.3) for Zn and 11.3 (SD 22.1) for folate.

Estimates of adequate intake (% \geq EAR) or potentially excessive intake (% \geq UL), considering micronutrients derived

Table 1. Prevalence of inadequate micronutrient intake among children of low socio-economic status at 2–3 years of age in Porto Alegre, Brazil* (Mean values and standard deviations; medians, minimum and maximum intake values)

Micronutrients	Means	SD	Median	Min–max	EAR	Inadequate intake	
						%	<i>n</i>
Vitamin A (µg/d)	501.0	286.8	437.6	75.7–2217.1	210	5.2	23
Vitamin C (mg/d)	47.4	33.4	38.6	2.6–361.2	13	4.7	21
Folate (µg/d)	195.6	78.0	187.3	52.3–638.1	120	15.2	68
Ca (mg/d)	911.3	353.4	892.9	184.8–2185.8	500	11.4	51
Fe (mg/d)	9.4	4.5	8.5	1.7–33.6	3	1.2	8
Zn (mg/d)	7.8	2.5	7.31	2.7–18.0	2.5	0	0

EAR, estimated average requirement.

* Prevalence of inadequate intake: the percentage of a group with usual intake less than the EAR.

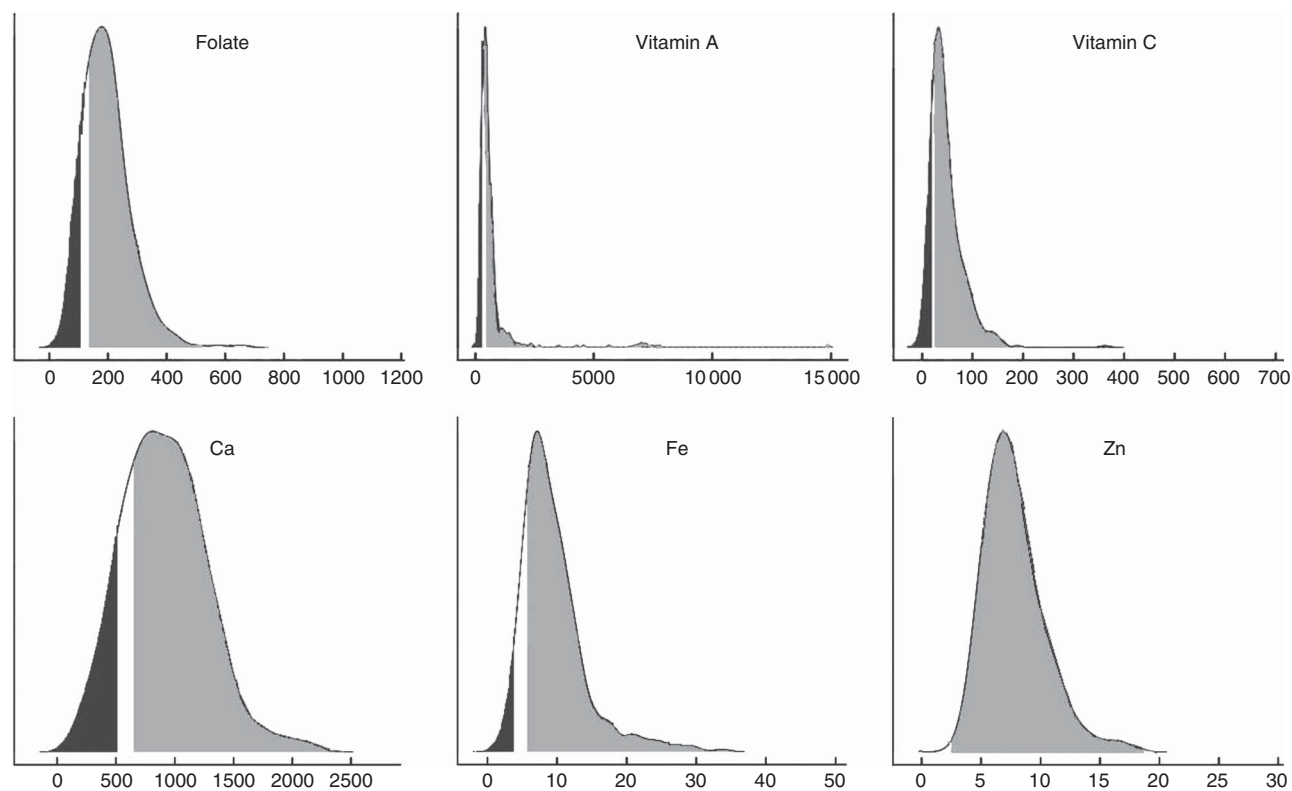


Fig. 2. Percentage of children at 2–3 years of age with usual micronutrient intakes below the estimated average requirement (EAR, ■) and above the RDA (□), in Porto Alegre, Brazil (*n* 446). EAR values: vitamin A (210 µg/d); vitamin C (13 mg/d); folate (120 µg/d); calcium (500 mg/d); iron (3 mg/d); zinc (2.5 mg/d). RDA values: vitamin A (300 µg/d); vitamin C (15 mg/d); folate (150 µg/d); calcium (700 mg/d); iron (7 mg/d); zinc (3 mg/d).

from fortified foods, are described in Table 3. In total, 43.0% (*n* 193) of the children met the EAR for Fe, 13.9% (*n* 62) for vitamin C and 12.3% (*n* 55) for Zn using fortified foods only. In addition, 4.0% (*n* 18) of the children exceeded the UL for vitamin A, 3.1% (*n* 14) for Zn, 1.1% (*n* 5) for folic acid and 0.2% (*n* 1) for Fe.

Discussion

This study highlights a low prevalence of inadequate micronutrient intake in children as a result of decreased consumption

of healthy foods and increased consumption of ultra-processed foods – the major contributors to micronutrient intake. These data are in accordance with the change in dietary patterns that has occurred in the last few years, which is displacing the traditional Brazilian diet that is based on wholesome foods and meals⁽⁴¹⁾. The drastic decrease in the consumption of healthy foods^(12–14) and concomitant increase in the consumption of ultra-processed foods in developed and developing countries such as Brazil can explain this new paradigm^(42–45). Many ultra-processed foods are fortified with vitamins and minerals, particularly those targeted at children. To our knowledge, there are no studies, in our country, that have evaluated the impact of

Table 2. Healthy food groups and the proportion of children who consume such foods and meet the intake recommendations among children of low socio-economic status at 2–3 years of age in Porto Alegre, Brazil (Mean values and standard deviations; medians, minimum and maximum intake values; percentages and numbers)

	Mean	SD	Median	Min–max	Intake		Meeting recommendations	
					%	n	%	n
Fruits (g)	103.9	58.8	94.0	18.3–389.5	83.6	374	2.5	11
Vegetables (g)	25.3	17.1	20.8	2.9–86.3	77.1	344	0	0
Beans (g)	74.7	40.4	71.4	9.4–247.3	87.7	391	80.5	359
Meats (g)*	65.3	21.3	63.3	22.2–144.4	98.7	440	35.4	158
Dairy products (ml)†	456.6	233.6	454.6	29.7–1300.1	95.9	428	28.3	126

* Meats: beef, chicken, pork, poultry, fish.

† Dairy products: milk and yogurt.

Table 3. Percentage of children at 2–3 years of age with usual micronutrient intakes above the estimated average requirement (EAR) and above the upper tolerable level (UL), considering only fortified foods, in Porto Alegre, Brazil (n 446)* (Percentages and numbers)

	EAR	≥EAR		UL	≥UL	
		%	n		%	n
Vitamin A (µg/d)	210	12.3	55	600	4.0	18
Vitamin C (mg/d)	13	13.9	62	400	–	–
Folate (µg/d)	120	4.3	19	300	1.1	5
Ca (mg/d)	500	4.0	18	2500	–	–
Fe (mg/d)	3	43.3	193	40	0.2	1
Zn (mg/d)	2.5	11.4	51	7	3.1	14

* Fortified foods = gelatin desserts, ready-to-eat cereal, soya juice, soya milk, powdered milk, powdered chocolate, baby cereal, petit suisse cheese.

ultra-processed foods on micronutrient intake among children. However, studies in the US have shown that fortified foods are the main contributors to nutrient intake in the diets of US children and adolescents^(46,47), especially ready-to-eat cereals⁽⁴⁸⁾. These study results showed that, without fortification and supplementation, many Americans do not achieve the recommended micronutrient intake levels set forth by the dietary reference intakes. Mandatory fortification of flour with Fe and folic acid was implemented as national policy in Brazil since 2002⁽⁴⁹⁾, although it did not impact on these micronutrient intakes among preschool children⁽⁵⁰⁾.

The consumption of ultra-processed foods poses the dilemma of how to minimise the proportion of individuals whose intakes are below the requirements without increasing the risk of consuming amounts above the UL⁽⁵¹⁾. The bio-availability of micronutrients depends on food composition and possibly on its encapsulation method. For example, ingredients for cereal fortification recommended by the WHO include ferrous sulphate, ferrous fumarate, ferric pyrophosphate and electrolytic Fe powder, which have good bioavailability⁽⁵²⁾. Furthermore, ultra-processed foods do not provide the same health benefits as natural foods⁽⁵³⁾. Beyond the addition of synthetic micronutrients that can exceed the UL, ultra-processed foods are energy-dense, with high levels of fat, sugar and/or Na⁽¹⁶⁾, contributing to the increased prevalence of obesity, whereas childhood malnutrition has declined dramatically^(54,55).

Some potential limitations should be discussed to fully appreciate our results. First, our results cannot be generalised to large populations because we only included children from

low-income groups. Second, the authors understand that the mean of two dietary recalls may not represent the entire distribution of usual intake due to the intra-individual variance component. Therefore, the dietary intake data have been corrected for inter- and intra-individual variability using the MSM method^(34,35). Third, there are no national dietary reference intakes, and therefore we applied the American references of Institute of Medicine^(36–40), which could overestimate the recommended intake for Brazilian children. However, our results indicated low percentages of children below the EAR.

In conclusion, children of low-income families enrolled in this study did not meet the consumption recommendations for healthy foods. On the other hand, ultra-processed foods had a notable influence on the low prevalence of micronutrient intake. Therefore, developing countries with widespread micronutrient deficiencies should confront new dietary patterns as a challenge and work to prevent such deficiencies without running the risk of excessive intakes. Investigations including blood tests for micronutrient deficiencies should be planned to confirm our hypothesis.

Acknowledgements

We thank the healthcare centres, healthcare workers and families who participated in the study.

This research received no specific grant from any funding agency or from commercial or not-for-profit sectors.

C. N. S. contributed to the data analyses, interpretation of the results, drafting and critical revision of the manuscript;

F. R. contributed to the drafting and critical revision of the manuscript; M. R. V. contributed to the research proposal, interpretation of the results, drafting and critical revision of the manuscript.

The authors declare that there are no conflicts of interest.

References

1. Singh M (2004) Role of micronutrients for physical growth and mental development. *Indian J Pediatr* **71**, 59–62.
2. Butte NF, Fox MK, Briefel RR, *et al.* (2010) Nutrient intakes of US Infants, toddlers and preschoolers meet or exceed dietary reference intakes. *J Am Diet Assoc* **110**, Suppl. 3, S16–S26.
3. Allen LH (1994) Nutritional influences on linear growth: a general review. *Eur J Clin Nutr* **48**, Suppl., 75–89.
4. Ronaghy H, Spivey Fox MR, Garn SM, *et al.* (1969) Controlled zinc supplementation for malnourished school boys: a pilot experiment. *Am J Clin Nutr* **22**, 1279–1289.
5. Rosado JL (1999) Separate and joint effect of micronutrient deficiencies on linear growth. *J Nutr* **129**, 531S–533S.
6. Tomkins A, Behrens R & Roy S (1993) The role of vitamin A and zinc deficiency in diarrhoeal syndromes in developing countries. a review. *Proc Nutr Soc* **52**, 131–142.
7. Rosado JL, López P, Muñoz E, *et al.* (1997) Zinc supplementation reduced morbidity, but neither zinc nor iron supplementation affected growth or body composition of Mexican preschoolers. *Am J Clin Nutr* **65**, 13–19.
8. Sandstead HH, Penland JG, Alcock NW, *et al.* (1998) Effects of repletion with zinc and other micronutrients on neuropsychologic performance and growth of Chinese children. *Am J Clin Nutr* **68**, Suppl., 470S–475S.
9. Lozoff B, Jimenez E & Wolf AW (1991) Long-term developmental outcome of infants with iron deficiency. *N Engl J Med* **325**, 687–694.
10. Uauy R, Kain J, Mericq V, *et al.* (2008) Nutrition, child growth, and chronic disease prevention. *Ann Med* **40**, 11–20.
11. World Health Organization (2004) *Focusing on Anaemia: Towards an Integrated Approach for Effective Anaemia Control* [Joint statement by the World Health Organization and the United Nations Children's Fund]. Geneva: WHO.
12. Lock K, Joceline P, Louise C, *et al.* (2005) The global burden of disease attributable to low consumption of fruit and vegetables: implications for the global strategy on diet. *Bull World Health Organ* **83**, 100–108.
13. Bachman JL, Reedy J, Subar AF, *et al.* (2008) Sources of food group intakes among the US population, 2001–2002. *J Am Diet Assoc* **108**, 804–814.
14. Wolfenden L, Wyse R, Campbell KJ, *et al.* (2014) Randomized controlled trial of a telephone-based intervention for child fruit and vegetable intake: long-term follow-up. *Am J Clin Nutr* **99**, 543–550.
15. Monteiro CA, Levy RB, Claro RM, *et al.* (2010) A new classification of foods based on the extent and purpose of their processing. *Cad Saude Publica* **26**, 2039–2049.
16. Monteiro CA & Cannon G (2014) The Food System: product reformulation will not improve public health. [Commentary]. *World Nutr* **5**, 140–168.
17. Environmental Working Group (2014) How much is too much? Excess vitamins and minerals in food can harm kids' health. http://www.environmentportal.in/files/file/too_much_of_a_good_thing.pdf (accessed November 2015).
18. Moodie R, Stuckler D, Monteiro C, *et al.* (2013) Profits and pandemics: prevention of harmful effects of tobacco, alcohol, and ultra-processed food and drink industries. *Lancet* **12**, 670–679.
19. Shamah T & Villalpando S (2006) The role of enriched foods in infants and child nutrition. *Br J Nutr* **96**, Suppl. 1, S73–S77.
20. Alexy U, Sichert-Hellert W, Rode T, *et al.* (2008) Convenience food in the diet of children and adolescents: consumption and composition. *Br J Nutr* **99**, 345–351.
21. Hennessy A, Walton J & Flynn A (2013) The impact of voluntary food fortification on micronutrient intakes and status in European countries: a review. *Proc Nutr Soc* **72**, 433–440.
22. Bueno MB, Fisberg RM, Maximino P, *et al.* (2013) Nutritional risk among Brazilian children 2 to 6 years old: a multicenter study. *Nutrition* **29**, 405–410.
23. Huffman S, Baker J, Shumann J, *et al.* (1999) The case for promoting multiple vitamin and mineral supplements for women of reproductive age in developing countries. *Food Nutr Bull* **20**, 379–394.
24. Allen LH (2005) Multiple micronutrients in pregnancy and lactation: an overview. *Am J Clin Nutr* **81**, S1206–S1212.
25. Black RE, Allen LH, Bhutta ZA, *et al.* (2008) Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet* **371**, 243–260.
26. Brazil Ministry of Health (2010) *[Dietary Guidelines for the Brazilian Population]*. Brasília: Ministry of Health (Secretaria de Atenção à Saúde, Coordenação Geral da Política de Alimentação e Nutrição).
27. Vitolo MR, Bortolini GA, Feldens CA, *et al.* (2005) Impacts of the 10 steps to healthy feeding in infants: a randomized field trial. *Cad Saude Publica* **21**, 1448–1457.
28. World Health Organization Multicentre Growth Reference Study Group (2006) WHO child growth standards based on length/height, weight and age. *Acta Paediatr Suppl* **450**, 76–85.
29. Center for Study and Research in Food (NEPA) (2006) *Brazilian Food Composition Table: TACO*. Campinas: State University of Campinas/Unicamp.
30. Philippi ST (2001) *Tabela de Composição de Alimentos: suporte para decisão nutricional (Adapted Food Pyramid: A Guide for a Right Food Choice)*. São Paulo: ANVISA, FINATEC/NUT-UnB.
31. Manios Y, Moschonis G, Grammatikaki E, *et al.* (2015) Food group and micronutrient intake adequacy among children, adults and elderly women in Greece. *Nutrients* **7**, 1841–1858.
32. Philippi ST, Latterza AR, Cruz AT, *et al.* (1999) Adapted food pyramid: a guide for a right food choice. *Rev Nutr* **12**, 65–80.
33. United States Department of Agriculture: Center for Nutrition Policy and Promotion (2011) MyPlate background. <http://www.choosemyplate.gov/> (accessed April 2016).
34. Harttig U, Haubrock J, Knüppel S, *et al.* (2011) The MSM program: web-based statistics package for estimating usual dietary intake using the Multiple Source Method. *Eur J Clin Nutr* **65**, S87–S91.
35. Haubrock J, Nöthlings U, Volatier J, *et al.* (2011) Estimating usual food intake distributions by using the Multiple Source Method in the EPIC-Potsdam Calibration Study. *J Nutr* **141**, 914–920.
36. Institute of Medicine (1998) *Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B₆, Folate, Vitamin B₁₂*. Washington, DC: National Academies Press.
37. Institute of Medicine (2000) *Dietary Reference Intakes: Application in Dietary Assessment*. Washington, DC: National Academies Press.
38. Institute of Medicine (2000) *Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids*. Washington, DC: National Academies Press.
39. Institute of Medicine (2001) *Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium and Zinc*. Washington, DC: National Academies Press.

40. Institute of Medicine (2011) *Dietary Reference Intakes for Calcium and Vitamin D*. Washington, DC: National Academies Press.
41. Levy RB, Claro RM, Mondini L, *et al.* (2012) Regional and socioeconomic distribution of household food availability in Brazil, in 2008–2009. *Rev Saude Publica* **46**, 6–15.
42. Monteiro CA, Levy RB, Claro RM, *et al.* (2011) Increasing consumption of ultra-processed foods and likely impact on human health: evidence from Brazil. *Public Health Nutr* **14**, 5–13.
43. Bortolini GA, Gubert MB & Santos LMP (2012) Food consumption Brazilian children by 6 to 59 months of age. *Cad Saude Publica* **28**, 1759–1771.
44. Nicklas TA, Demory-Luce D, Yang SJ, *et al.* (2004) Children's food consumption patterns have changed over two decades (1973–1994): The Bogalusa heart study. *J Am Diet Assoc* **104**, 1127–1140.
45. Martins APB, Levy RB, Claro RM, *et al.* (2013) Increased contribution of ultra-processed food products in the Brazilian diet (1987–2009). *Rev Saude Publica* **47**, 656–665.
46. Berner LA, Keast DR, Bailey RL, *et al.* (2014) Fortified foods are major contributors to nutrient intakes in diets of US children and adolescents. *J Acad Nutr Diet* **114**, S2212–S2672.
47. Fulgoni VL, Keast DR, Bailey RL, *et al.* (2011) Foods, fortificants, and supplements: where do Americans get their nutrients? *J Nutr* **141**, 1847–1854.
48. Fulgoni VL & Buckley RB (2015) The contribution of fortified ready-to-eat cereal to vitamin and mineral intake in the U.S. populations, NHANES 2007–2010. *Nutrients* **7**, 3949–3958.
49. National Health Surveillance Agency (ANVISA) (2002) Resolution RDC no. 344 of December 2002. Technical Regulation for fortification of wheat and maize flour with iron and folic acid. http://bvsms.saude.gov.br/bvs/saudelegis/anvisa/2002/rdc0344_13_12_2002.html (accessed June 2016).
50. Assunção MC, Formoso IS, Barros AJD, *et al.* (2007) Effect of iron fortification of flour on anemia in preschool children in Pelotas, Brazil. *Rev Saude Publica* **41**, 539–548.
51. Bruins JB, Mugambi G, Verkaik-Kloosterman J, *et al.* (2015) Addressing the risk of inadequate and excessive micronutrients intakes: traditional versus new approaches to setting adequate and safe micronutrient levels in foods. *Food Nutr Res* **59**, 26020.
52. Allen L, de Benoist B, Dary O, *et al.* (2006) *Guidelines on Food Fortification with Micronutrients*. Geneva: WHO.
53. Jacobs DR Jr & Tapsell LC (2013) Food synergy: the key to a healthy diet. *Proc Nutr Soc* **72**, 200–206.
54. Popkin BM (1993) Nutritional patterns and transitions. *Popul Dev Rev* **19**, 138–157.
55. Batista Filho ME & Rissin A (2003) Nutritional transition in Brazil: geographic and temporal trends. *Cad Saude Publica* **19**, Suppl. 1, 181–191.