Distribution of macro- and micronutrient intakes in relation to the meal pattern of third- and fourth-grade schoolchildren in the city of Quetzaltenango, Guatemala

Marieke Vossenaar[1],*†, Gabriela Montenegro-Bethancourt[1,2], Lothar DJ Kuijper[2], Colleen M Doak[2] and Noel W Solomons[1]

[1]Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM), Guatemala City, Guatemala:
[2]Health Sciences Institute, Vrije Universiteit, Amsterdam, The Netherlands

Abstract

Objective: Our objective was to assess the distribution of energy, macro- and micronutrient intakes by meal (breakfast, lunch, dinner and combined snacks) in a cross-sectional sample of schoolchildren.
Design: Cross-sectional dietary survey in schoolchildren.
Setting: Twelve private and public schools in the urban setting of Quetzaltenango, Guatemala.
Subjects: A total of 449 schoolchildren (from higher and lower socio-economic strata) were enrolled in the study.
Methods: Each child completed a single, pictorial 24 h prospective diary and a face-to-face interview to check completeness and estimate portion sizes. Estimated daily intakes were examined by mealtime as: (i) absolute intakes; (ii) relative nutrient distribution; and (iii) critical micronutrient density (i.e. nutrient density in relation to the WHO Recommended Nutrient Intakes/median age-specific Guatemalan energy requirements).
Results: The daily distribution of energy intake was 24 % at breakfast, 30 % at lunch, 23 % at dinner and 23 % among snacks. Lunch was also the leading meal for macronutrients, providing 35 % of proteins, 27 % of fat and 30 % of carbohydrate. The distribution of selected micronutrients did not follow the pattern of energy, insofar as lunch provided relatively more vitamin C and Zn, whereas breakfast led in terms of vitamins A and D, thiamin, riboflavin, folate, Ca and Fe.
Conclusions: Meal-specific distribution of energy, macro- and micronutrients provides a unique and little used perspective for evaluation of children's habitual intake, and may provide guidance to strategies to improve dietary balance in an era of coexisting energy overnutrition and micronutrient inadequacy.

Dietary intake is a major determinant of both the nutritional status and the general health and well-being of an individual. An optimal diet will supply adequate – but not excessive – amounts of all essential nutrients, while maximizing foods and dietary substances that promote long-term health and avoiding dietary constituents related to ill health[1]. Both greater dietary variety (number of different foods and beverages consumed) and dietary diversity (selection from an array of food groups) are associated with more nutritious and more healthful intake patterns[2]. What is an inherent reality is that foods are consumed in various meals and meal settings over the course of a day. Moreover, factors of household economics, cultural and culinary conventions and personal convenience will dictate the frequency, size and composition of the meals consumed throughout the day.

A few investigators have analysed individual meal contributions to the day's intake of macro- or micronutrients. These pioneering studies identified dietary patterns that deviate strongly from recommended population nutrient goals in children[3–5], adolescents[6,7] and adults[8]. The studies on children and adolescents are mostly European studies. The findings emphasize the difference in nutritional value of meals and the association between breakfast consumption and better dietary quality. Unfortunately, no similar results are available for children or adolescents in Guatemala, or even in the broader region. However, studies show a prevailing trend of snack-dominated meal patterns, associated with higher

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† Postal address: CeSSIAM in Guatemala, c/o PO Box 02-5339, Section 3163/Guatemala, Miami, FL 33102-5339, USA.

Corresponding author: Email mvossenaar@hotmail.com

intakes of foods with lower nutrient density (i.e. high in fats and sugars, but low in micronutrients). Further concerns include irregular meal patterns, such as meal skipping, and high fat content in lunch and snacks, patterns to be explored in the present study.

Consumption patterns that are too poor or too rich in macro- or micronutrients, excessive in harmful foods and noxious ingredients, and insufficient in health-protective elements might need to be corrected through education and health interventions. Therefore, knowing the pattern of meals and the nutrient density of these meals might help provide the necessary leverage for corrective change. In Guatemala, micronutrient-enriched products such as micronutrient-fortified cereals as well as sugar fortified with retinyl palmitate are potential major sources of micronutrients for children. However, little is known about how these products are consumed in terms of timing (meal pattern), frequency and quantity.

During a 3-month period in the summer of 2005, 24 h registries of all food and beverage intake were obtained by interactive, pictorial self-recording by children in the third and fourth grades of public and private schools of the city of Quetzaltenango in the western highlands of Guatemala. Our objective was to assess and describe the intakes of energy and main macronutrients across the different eating opportunities in the children's day, and to relate them the intake of selected micronutrients from the different meals. Below we describe in detail the procedures used to achieve our aim and our findings of meal patterns' nutrient contributions across social class and gender in this survey of urban Guatemalan schoolchildren. Micronutrient density is particularly important in the diet of children, who require nutrient-dense foods for healthy physical and mental development. Identifying the contribution of foods according to meal type is helpful for identifying the relative contribution of micro- and macronutrients to the diets of children.

Subjects and methods

Subject selection

A total of five public schools, stratified as lower socio-economic status (LSES), and eleven private schools, stratified as higher socio-economic status (HSES), were invited to participate in the study. Within these schools, only children attending third and fourth grades were recruited.

The nature of the study was explained to the teachers and students in the classroom during usual school hours. The children's legal guardians were informed about the study in writing. They were told that the main objective of the study was to assess usual fruit and vegetable consumption in schoolchildren. Incentives to participate included a free snack (either a bread-based meal or cereal) and the children were allowed to keep the crayons provided for the study.

The study was approved by the Human Subjects Committee of the Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM), Guatemala City and the local education authorities. Only children with a signed consent form from their legal guardians were included in the study.

Questionnaire and sample collection

A single pictorial 24 h prospective diary was collected from April to June 2005. The data collection instrument is a 5-page booklet designed to assess dietary intake with a 24 h time frame. The first page contains written instructions on how to complete the questionnaire. The subject is instructed to draw all the food and drink items consumed within a 24 h time frame and to include all items consumed between meals (snacks) both at school and at home. Children were asked to record all drink and food items consumed since the last meal and for 24 h thereafter. The children were asked to take the booklets home and draw all food and drinks consumed (including candies) and to specify brands and amounts consumed. On the following day, the subjects were interviewed by a research nutritionist, who checked for completeness and estimated the portions of items listed. This interview helped to clarify the described articles and to quantify the food intake by using food models and common household measures. Children who forgot to bring the workbook were given another booklet for that day and the interview was done the next day. All data were recorded on school days and all meals consumed at school were brought from home or bought at the school snack shop. No school lunch was provided, as a usual school day ends at 13.00 hours.

Although the data collection tool was not validated, the instrument and methodology used for data collection were previously used in studies conducted by CeSSIAM in urban schoolchildren from Guatemala City. The estimated median energy intake for the population, of 7829 kJ/d (1870 kcal/d; data not shown), was in close agreement with the WHO recommendations for this age group[9]. Our estimate median protein intake of 65 g/d was twice the Recommended Dietary Allowance for this age group[10].

Data analysis

Each food or beverage item reported was coded and entered into a database according to mealtime (breakfast, lunch, dinner or snack). All food and beverages items were codified separately according to preparation or presentation. Different commercial brand names of fruit juices, ready-to-eat cereals, etc. were coded as separate food items. A total of 218 items were listed and their nutrient values were derived primarily from the Central American food composition table (FCT)[11] and secondly from the US Department of Agriculture (USDA) FCT obtained online from the USDA National Nutrient Database for Standard Reference version 16·1 (www.nal.usda.gov/fnic/foodcomp/data). Nutritional

content of some products, such as ready-to-eat cereals, were updated. Nutrient values for food items not listed in the FCT were taken from the food labels or other manufacturer data. Typical dishes and composite foods were obtained from everyday Guatemalan recipe books[12–14] and their nutrient data were added to the FCT.

In order to provide a context to the food culture of the samples of schoolchildren, an illustration of the selection of the principal food and beverage contributors was assembled. For each meal and as disaggregated by gender and socio-economic status (SES) sub-samples, we calculated the cumulative contribution of energy for each food and beverage item reported within that subgroup. We constructed a 4×4 panel table by meal and by subgroup, with each panel including the top ten leading contributors to that meal.

The daily distribution of energy, macronutrients and selected micronutrients intakes (vitamin A, vitamin C, vitamin D, thiamin, riboflavin, folate, Ca, Fe and Zn) throughout the day (i.e. breakfast, lunch, dinner and combined snacks) was examined. The mean absolute nutrient intakes and their standard deviations are provided for reference in the Appendix. The focus of analysis, in accordance with the aim of the study, was to assess the distribution of energy, macro- and micronutrients intakes across meals. The focus here was testing differences between the meals (breakfast, lunch, dinner and combined snacks) within each SES or gender group. It was not our intention to generate comparisons within meals across LSES and HSES and girls and boys.

In keeping with the goal of our study, the analysis focuses first on the percentage of the daily intake of a nutrient that a given meal contributes. Thus, we calculated the subject's consumption of a given nutrient for that meal, divided by the subject's total daily intake of the nutrient and multiplied by 100. These individual meal-based percentages are presented by SES and gender with comparisons of results for meals classified as breakfast, lunch, dinner and snacks. Next, we compared the percentage contribution for nutrients with the meal's contribution to energy intake. These proportions were used for a comparative approach to identify the meals where a particular nutrient contribution fell below the overall energy contribution. If nutrient and energy intakes are proportional, the percentage nutrient and total energy contributions should match, one-to-one. In order to assess nutrients that contributed proportionately above or below the day's nutrient intake, relative to the energy contribution, we arbitrarily defined cut-offs that were 25 % above or below the energy contribution. Thus, a ratio of less than 0·75:1 identifies the meal as contributing relatively less of a nutrient relative to that meal's energy contribution. An elevated nutrient contribution of greater than 1·25:1 identifies a meal that contributes proportionately more of a nutrient relative to the meal's energy contribution. For this pattern analysis, we simply tabulated the number of ratios that fell into our pre-established deviant range.

The second analysis, focusing on meal-based nutrient densities, assesses each nutrient relative to the total energy contributed by that meal. Thus, the nutrient consumed at each meal was divided by the total energy. The resulting measure, the meal's nutrient contribution expressed per 4·187 kJ (1 kcal) consumed, was then multiplied by 1000. As with meal-based percentage intake, energy densities are presented separately for each nutrient, with results stratified by SES and gender, and statistical comparisons are based on differences between the four meals: breakfast, lunch, dinner and snacks.

The final measure compares nutrient densities against estimated nutrient intakes, using a new measure we call 'critical densities' modelled after the 1986 Working Group of the Cavendas Foundation for nutrient requirements in Latin America[15]. Critical densities were defined as the estimated recommended nutrient intakes, expressed per 4187 kJ (1000 kcal), and representing the amount of the respective nutrients that would achieve the recommended intake when an individual consumed the normative daily energy intake for his or her age and gender group. They were computed for selected micronutrients based on the WHO/FAO Recommended Nutrient Intakes (RNI)[16] and the energy requirements for children proposed by the Institute of Nutrition of Central America and Panama[17]. The RNI values were 500 retinol activity equivalents for vitamin A, 35 mg for vitamin C, 5 μg for vitamin D, 0·9 mg for thiamin, 0·9 mg for riboflavin, 300 dietary folate equivalents for folate, 700 mg for Ca, 9 mg for Fe and 5·6 mg for Zn. These nutrient recommendations were normalized to a 4187 kJ (1000 kcal) unit based on the estimated daily energy requirements. Thus, recommended nutrient intakes were divided by energy intake needs estimated to be 7850 kJ (1875 kcal) for boys and 6908 kJ (1650 kcal) for girls. Mean nutrient densities of gender and SES subgroups for each mealtime were then compared with the estimated critical densities, based on group means. Mean estimated intakes below the computed critical densities were considered inadequate.

Statistical methods

Data were analysed with the SPSS statistical software package version 11·0 (SPSS Inc., Chicago, IL, USA). As described above, the analysis focuses on the daily distribution of energy, macronutrients and selected micronutrients intakes (as a proportion of total daily intake) and nutrient densities, per meal. We used repeated-measures ANOVA to examine statistically significant differences in daily nutrient intake distributions and nutrient density distributions between mealtimes (i.e. breakfast, lunch, dinner and combined snacks) within subjects. The focus is testing differences between the meals within each SES and gender subgroup. We considered a probability of 5 % to be significant.

Results

Study population

All five public schools and seven schools invited agreed to participate and were included in the study. The total number of schoolchildren attending third and fourth grades in these twelve schools was 1124 (624 LSES, 500 HSES) and the majority of children were between 8 and 10 years old. A large proportion of children (n 675, 60%) did not participate in the study for various reasons such as falling outside the age criteria, absence on the day of data collection, 'forgetting' the consent form or leaving the data collection booklet at home. The final sample comprised 449 (40%) children, 219 (49%) of LSES (113 girls and 106 boys) and 230 (51%) of HSES (119 girls and 111 boys).

Principal energy sources of one day's meal-associated intakes

In order to understand the nutritional partition among meals, it is important to know the context of the foods in the meals. Table 1 presents the ten principal food and beverage contributors to the total energy of each class of meal: breakfast, lunch, dinner and snacks. A modal breakfast comprised breakfast cereals and milk with added sugar. Corn tortillas or white bread with fried eggs were also commonly eaten, especially by LSES children. Corn tortillas, a staple food consumed in all three meals, contributed up to 17·5% of the total energy in LSES boys for lunch. Main energy sources for lunch included chips, white rice and vegetable stew with chicken or beef. Main energy sources for dinner included corn tortilla, sweet bread, coffee with added sugar and fried eggs. Popular snacks included pizza, white bread, crisps and cola drinks.

Estimated proportion of one day's energy and macronutrient contribution by mealtime

Means of estimated 1 d intakes of energy and macronutrients by mealtime (i.e. breakfast, lunch, dinner and snacks) are presented as proportions of total daily intake in Table 2. We used repeated-measures ANOVA to examine differences in energy, macronutrient and selected micronutrient distributions between mealtimes (breakfast, lunch, dinner and combined snacks) within subjects. Meal compositions were compared within each of the four subgroups, i.e. HSES boys, LSES boys, HSES girls and LSES girls. Analyses were run separately, testing meal pattern contributions for energy, protein and fat. Of these twelve computations, a significant difference was found in the meals for all macronutrients ($P < 0·001$) except fat in LSES girls ($P = 0·194$). Lunch led in terms of energy ($P < 0·001$), protein ($P < 0·001$) and carbohydrates ($P < 0·001$), in all gender and SES subgroups. Lunch led in terms of fat in HSES boys ($P < 0·001$), whereas breakfast in LSES boys ($P = 0·038$) and dinner and snacks in HSES girls ($P = 0·022$) were more important

sources of fat. Mean energy intake from lunch ranged from 2319 kJ (554 kcal; 32% of energy) in LSES girls to 2700 kJ (645 kcal; 29% of energy) in HSES boys. Dinner and snacks were the lowest sources of energy. Mean energy intake from snacks was between 1562 kJ (373 kcal; 19% of energy) in LSES girls up to 2244 kJ (536 kcal; 27% of energy) in HSES boys (Appendix). With respect to the macronutrient:energy ratios, there were few, if any, ratios outside the established boundary limits for the meal-wise fat:energy and carbohydrate:energy percentage ratios. For protein, however, the ratio approached, but did not exceed 1·25, for lunch across the subgroups, and fell clearly below the 0·75 limits for snacks (data not shown).

Estimated proportion of one day's micronutrient contribution by mealtime

Means of estimated 1 d intakes of selected micronutrients by mealtime (i.e. breakfast, lunch, dinner and snacks) are presented as proportions of total daily intake in Table 2. We performed within-column repeated-measures ANOVA among the percentage contributions of the four meals for the thirty-six quartets of data involving micronutrients (nine micronutrients by gender and SES). Of these thirty-six computations, a significant difference within the foursome was found for all micronutrients examined ($P < 0·001$). In general, although lunch led numerically in terms of energy and most macronutrients, it was not the most micronutrient-dense meal. Lunch was the leading source only for vitamin C and Zn in all gender and SES subgroups and folate for LSES girls only. Breakfast led in terms of all other micronutrients examined (i.e. vitamin A, vitamin D, thiamin, riboflavin, folate, Ca and Fe) for all gender and SES subgroups. In general, snacks were the poorest source of all micronutrients.

Turning to a less formally statistical pattern analysis for micronutrients, the 144 ratio values for the percentage contribution of the three macronutrients and nine micronutrients to their corresponding mealtime percentage energy contribution for each specific meal were examined with respect to the boundary criteria. A total of seventy-nine (55%) were acceptably close to the nutrient:energy contribution concordance ratio of 1:1. An additional thirty-seven (26%) fell below 0·75:1 and twenty-eight (19%) were above 1·25:1 (data not shown). Protein:energy ratio in snacks was an example of a consistently below-criterion ratio, as were the corresponding ratios for vitamin D:energy at lunch and in snacks. In general, snacks had the lowest energy contribution ratios for micronutrients, and this was consistent across all gender and SES groups for vitamins A and D, thiamin and Zn. Breakfast was often a meal in which the nutrient:energy contribution ratios greatly exceeded the boundary criterion, a pattern that was consistent across all gender and SES groups for vitamins A and D, Ca and Fe.

Table 1 Main sources of daily energy by mealtime, gender and socio-economic status: third- and fourth-grade schoolchildren from Quetzaltenango, Guatemala, 2005

		Boys (n 217)				Girls (n 232)			
		HSES (n 111)		LSES (n 106)		HSES (n 119)		LSES (n 113)	
		Food item	%*	Food item	%*	Food item	%*	Food item	%*
Breakfast	1	Fluid whole milk with sugar†‡	16·9	Corn tortilla	11·7	Fluid whole milk with sugar	20·3	Wheat sweet bread (*pan de manteca*)	14·3
	2	Fried eggs	16·2	Fried eggs	10·9	Fluid whole milk	12·5	Fluid whole milk with sugar	14·0
	3	RTE cereal corn flakes	9·2	Fluid whole milk with sugar	9·5	RTE cereal corn flakes	9·0	Nutritive beverage (*incaparina*)	9·1
	4	Fried eggs	6·7	Wheat sweet bread (*pan de manteca*)	7·0	Nutritive beverage (*incaparina*)	7·0	Coffee with sugar	7·5
	5	Wheat sweet bread (*pan de manteca*)§	5·6	Artificial drink brand T¶	6·8	Fried eggs	4·7	Fried eggs	7·1
	6	French-type bread	3·4	French-type bread	4·9	RTE chocolate puffed rice cereal	3·7	Corn tortilla	5·8
	7	Nutritive beverage (*incaparina*)||	3·2	Coffee with sugar	4·8	French-type bread	3·4	RTE cereal corn flakes	3·6
	8	Natural orange juice	2·8	Boiled beans	4·6	Wheat sweet bread (*pan de manteca*)	3·3	Corn-based tamale (*tamalito*)	2·9
	9	Vitamin A-fortified sugar table	2·7	RTE cereal corn flakes	4·4	Banana	3·1	French-type bread	2·4
	10	RTE chocolate puffed rice cereal	2·5	Fluid whole milk	3·4	Coffee with sugar	2·6	Fresh cheese	2·2
Lunch	1	French fries	10·4	Corn tortilla	17·5	Corn tortilla	10·1	Corn tortilla	11·7
	2	Corn tortilla	9·7	French fries	8·9	White rice	6·6	Chicken and vegetables stew	7·9
	3	Chicken and vegetables stew	6·3	White rice	5·5	Beef and vegetables stew	5·8	Beef and vegetables stew	6·0
	4	Grilled beef	5·5	Chicken and vegetables stew	5·0	Pasta and tomato sauce	4·9	Corn-based tamale (*tamalito*)	5·6
	5	White rice	4·8	Beef and vegetables stew	4·8	French fries	4·4	Typical spicy tomato gravy (*recado*)	4·4
	6	Pasta and tomato sauce	4·1	Artificial drink brand T	4·6	Grilled beef	4·1	French fries	4·2
	7	Lemonade	3·7	Fried chicken	3·8	Ground beef	3·3	White rice	4·2
	8	Beef and vegetables stew	2·7	Grilled beef	3·5	Fried chicken	3·2	Pasta and tomato sauce	4·0
	9	Boiled chicken	2·6	Corn-based tamale (*tamalito*)**	3·2	Chicken and vegetables stew	3·2	Maize gruel (*atole de masa*)	3·2
	10	Fried chicken	2·0	Boiled beans	2·5	Lemonade	3·1	Artificial drink brand T	2·9
Dinner	1	Fried eggs	8·7	Wheat sweet bread (*pan de manteca*)	13·5	Fried plantain	6·6	Coffee with sugar	8·5
	2	Pizza	6·0	Corn tortilla	11·3	Wheat sweet bread (*pan de manteca*)	6·1	Wheat sweet bread (*pan de manteca*)	8·3
	3	Corn tortilla	6·0	Coffee with sugar	7·6	Corn tortilla	5·6	Corn tortilla	7·8
	4	Fluid whole milk	5·2	French-type bread	5·3	French fries	5·5	French fries	4·9
	5	French fries	4·2	Fried eggs	4·4	Coffee with sugar	5·3	Corn-based tamale (*tamalito*)	4·9
	6	Wheat sweet bread (*pan de manteca*)	4·2	Boiled beans	4·0	Butter	5·2	Fried eggs	4·3
	7	French-type bread	3·7	Fresh cheese	3·7	Fluid whole milk	4·9	Fresh cheese	3·5
	8	Cooked beans	3·5	Corn-based tamale (*tamalito*)	3·5	French fries	3·5	Fried plantain	3·4
	9	Coffee with sugar	2·9	Nutritive beverage (*incaparina*)	2·9	Hot dog sausage	3·4	Grilled beef	3·4
	10	Fried plantain	2·9	Cooked beans	2·9	Boiled beans	3·2	Chocolate drink (from tablet)	3·0
Snacks	1	Pizza	8·0	Wheat sweet bread (*pan de manteca*)	14·6	White sliced bread	7·2	Wheat sweet bread (*pan de manteca*)	7·9
	2	White sliced bread	7·0	Fried corn snacks	7·5	Wheat sweet bread (*atole de masa*)	6·0	Maize gruel (*atole de masa*)	7·4
	3	Snacks corn-based nacho flavour	5·8	Snacks corn-based nacho flavour	6·5	Soda cola brand C	3·7	Doughnuts	6·2
	4	Packed fruit juice brand D	3·8	Oatmeal gruel	5·2	Packed fruit juice brand D	3·3	French fries	4·9
	5	Corn-based snack brand D	3·7	Banana	4·2	Fried corn snacks	3·2	Chocolate drink (from tablet)	4·7
	6	Non-cola soda drink	3·6	Maize gruel (*atole de masa*)††	4·0	American-type cheese	2·8	Corn tortilla fried	4·5
	7	American-type cheese	3·4	Rice and milk gruel	3·3	Hot dog sausage	2·7	Rice and milk gruel	4·4
	8	Cured ham	2·6	Wheat cookie-type bread	2·9	Fluid whole milk	2·6	Peanuts	3·7
	9	Wheat sweet bread (*pan de manteca*)	2·6	Non-cola soda drink	2·5	Cured ham	2·5	French-type bread	3·3
	10	Cream-filled chocolate cookies	2·5	Snacks cheese flavour	2·1	French-type bread	2·2	Ice cream	2·8

HSES, higher socio-economic status; LSES, lower socio-economic status; RTE, ready-to-eat.

*Food item as a proportion of energy consumed during that meal (%).

†Fluid whole milk with sugar: specifically coded as the milk added to cereals.

‡Sugar: granulated sugar is fortified with vitamin A by Guatemalan law at 10 retinol activity equivalents/g.

§Wheat sweet bread (*pan de manteca*): a staple containing wheat flour, sugar and shortening.

||Nutritive beverage (*incaparina*): a protein-rich popular gruel based on corn and soya with added micronutrients.

¶Artificial drink: any of the sweetened fruit-flavoured non-carbonated beverages often fortified with vitamin C.

**Corn-based tamale (*tamalito*): lime-treated corn dough baked in corn leaves.

††Maize gruel (*atole de masa*): lime-treated corn dough prepared as beverage.

Table 2 Distribution (as a proportion of total daily intake) of estimated 1 d intakes of energy, macronutrients and selected micronutrients by mealtime, gender and socio-economic status: third- and fourth-grade schoolchildren from Quetzaltenango, Guatemala, 2005

| | Boys (n 217) | | | | | | | | Girls (n 232) | | | | | | | |
| | HSES (n 111) | | | LSES (n 106) | | | | HSES (n 119) | | | LSES (n 113) | | | |
	Mean	SD	P*	Mean	SD	P*	Mean	SD	P*	Mean	SD	P*
Energy												
Breakfast	22	9		27	12		21	10		25	10	
Lunch	32	12		30	10		29	9		29	11	
Dinner	23	11		23	11		22	10		25	10	
Snack	23	11	<0·001	19	11	<0·001	27	13	<0·001	21	12	<0·001
Protein												
Breakfast	21	10		30	14		22	14		25	15	
Lunch	38	16		33	14		36	15		34	14	
Dinner	25	15		25	14		23	13		27	14	
Snack	16	14	<0·001	12	12	<0·001	19	13	<0·001	14	11	<0·001
Fat												
Breakfast	21	11		28	16		21	12		24	14	
Lunch	30	16		26	16		26	14		27	17	
Dinner	25	16		24	15		27	17		26	15	
Snack	24	15	<0·001	22	17	0·038	27	17	0·022	23	18	0·194
Carbohydrate												
Breakfast	23	12		27	14		22	12		25	12	
Lunch	31	14		30	12		29	12		29	12	
Dinner	21	12		23	13		20	11		23	12	
Snack	24	12	<0·001	21	11	<0·001	29	14	<0·001	23	12	0·004
Vitamin A												
Breakfast	40	22		38	17		35	21		34	18	
Lunch	27	23		26	20		29	21		26	19	
Dinner	25	19		22	14		22	17		24	14	
Snack	9	11	<0·001	14	15	<0·001	13	14	<0·001	15	15	<0·001
Vitamin C												
Breakfast	29	28		26	29		24	27		17	25	
Lunch	37	30		36	34		31	27		39	33	
Dinner	12	17		19	25		15	22		17	23	
Snack	23	29	<0·001	17	25	<0·001	30	31	<0·001	27	33	<0·001
Vitamin D												
Breakfast	60	27		55	36		51	33		43	39	
Lunch	10	17		12	24		9	16		12	23	
Dinner	24	23		17	26		29	31		26	32	
Snack	6	15	<0·001	8	21	<0·001	10	19	<0·001	11	22	<0·001
Thiamin												
Breakfast	31	18		33	17		32	20		29	20	
Lunch	30	17		30	16		28	16		30	18	
Dinner	21	15		24	16		20	17		24	16	
Snack	18	15	<0·001	13	12	<0·001	20	17	<0·001	17	15	<0·001
Riboflavin												
Breakfast	39	21		42	27		40	23		30	25	
Lunch	26	23		24	24		20	19		29	26	
Dinner	23	19		22	24		24	20		29	27	
Snack	13	13	<0·001	12	16	<0·001	16	16	<0·001	10	13	<0·001
Folate												
Breakfast	36	20		36	23		36	22		25	21	
Lunch	28	20		29	22		26	20		36	24	
Dinner	20	16		20	19		20	18		22	18	
Snack	15	15	<0·001	14	17	<0·001	18	17	<0·001	17	18	<0·001
Ca												
Breakfast	41	20		35	22		41	24		33	23	
Lunch	19	15		26	18		16	14		26	18	
Dinner	24	19		24	19		23	20		24	18	
Snack	15	15	<0·001	15	15	<0·001	20	19	<0·001	16	16	<0·001
Fe												
Breakfast	39	19		35	19		37	20		34	20	
Lunch	25	15		21	14		23	13		25	16	
Dinner	22	14		25	16		22	14		21	14	
Snack	14	10	<0·001	18	13	<0·001	18	14	<0·001	20	14	<0·001
Zn												
Breakfast	24	15		28	16		28	19		26	21	
Lunch	39	19		35	17		34	19		33	19	
Dinner	23	16		23	19		22	15		25	18	
Snack	15	15	<0·001	14	15	<0·001	16	16	<0·001	16	17	<0·001

HSES, higher socio-economic status; LSES, lower socio-economic status.
*P value from repeated-measures ANOVA.

Nutrient density by mealtime

Table 3 illustrates mean values and standard deviations for the selected nutrient densities in each mealtime by gender and SES group. We used repeated-measures ANOVA to examine differences in density distributions between mealtimes (breakfast, lunch, dinner and combined

Table 3 Nutrient densities of estimated 1 d intakes of macronutrients and selected micronutrients by mealtime, gender and socio-economic status: third- and fourth-grade schoolchildren from Quetzaltenango, Guatemala, 2005

	Boys (n 217)						Girls (n 232)					
	HSES (n 111)			LSES (n 106)			HSES (n 111)			LSES (n 106)		
Density (per 4187 kJ/1000 kcal)	Mean	SD	P	Mean	SD	P	Mean	SD	P	Mean	SD	P
Protein (g)												
Breakfast	34	11		36	12		32	12		31	15	
Lunch	45	26		38	21		45	26		40	24	
Dinner	39	20		36	22		36	19		35	21	
Snack	23	16	<0·001	19	16	<0·001	22	14	<0·001	20	14	<0·001
Fat (g)												
Breakfast	30	11		30	15		28	13		28	13	
Lunch	30	15		25	17		27	15		28	16	
Dinner	34	17		28	16		36	18		31	15	
Snack	31	15	0·198	27	16	0·206	28	14	<0·001	27	17	0·275
Carbohydrate (g)												
Breakfast	153	34		151	40		153	47		156	38	
Lunch	143	43		158	48		150	46		154	47	
Dinner	132	55		144	55		131	50		144	44	
Snack	157	49	<0·001	164	58	0·034	166	46	<0·001	167	55	0·003
Vitamin A (RAE)												
Breakfast	804	566		669	375		797	376		671	313	
Lunch	549	969		478	664		591	548		567	779	
Dinner	517	434		420	330		543	432		496	349	
Snack	234	387	<0·001	339	362	<0·001	275	309	<0·001	383	379	<0·001
Vitamin C (mg)												
Breakfast	72	104		41	116		61	98		17	23	
Lunch	69	115		35	50		66	103		71	138	
Dinner	28	61		19	36		30	65		22	44	
Snack	85	170	<0·001	42	123	0·020	89	136	<0·001	75	147	<0·001
Vitamin D (μg)												
Breakfast	4·8	2·5		2·6	2·3		4·1	2·8		2·1	2·3	
Lunch	0·5	0·9		0·4	0·8		0·5	0·8		0·5	0·9	
Dinner	2·0	2·3		0·8	1·3		1·9	2·1		1·1	1·3	
Snack	0·4	0·9	<0·001	0·5	1·4	<0·001	0·6	1·0	<0·001	0·5	0·9	<0·001
Thiamin (mg)												
Breakfast	0·9	0·6		0·7	0·6		1·0	0·6		0·7	0·6	
Lunch	0·5	0·3		0·5	0·4		0·6	0·4		0·6	0·5	
Dinner	0·5	0·3		0·5	0·3		0·5	0·4		0·5	0·4	
Snack	0·5	0·5	<0·001	0·4	0·5	<0·001	0·5	0·4	<0·001	0·4	0·5	0·005
Riboflavin (mg)												
Breakfast	2·3	2·7		2·7	4·7		2·0	1·2		2·8	4·8	
Lunch	1·6	2·8		2·2	4·8		1·1	2·1		3·9	6·5	
Dinner	1·6	3·5		2·4	5·6		1·6	3·0		4·5	8·2	
Snack	0·6	0·5	<0·001	0·6	0·6	0·002	0·6	0·5	<0·001	0·5	0·6	<0·001
Folate (DFE)												
Breakfast	240	155		184	196		235	139		117	114	
Lunch	134	146		117	116		126	105		126	98	
Dinner	120	96		104	109		118	95		92	87	
Snack	87	96	<0·001	95	132	<0·001	84	80	<0·001	96	141	0·073
Ca (mg)												
Breakfast	881	475		486	350		853	479		533	428	
Lunch	245	185		297	272		239	207		351	441	
Dinner	485	451		325	320		474	452		379	429	
Snack	278	252	<0·001	281	303	<0·001	301	291	<0·001	272	268	<0·001
Fe (mg)												
Breakfast	15·8	11·3		10·5	8·9		14·5	8·8		9·7	7·5	
Lunch	6·3	3·9		4·7	2·9		6·2	3·7		7·8	18·1	
Dinner	7·0	5·0		6·5	4·0		6·8	4·4		5·6	3·6	
Snack	4·6	3·1	<0·001	6·4	5·6	<0·001	5·1	3·9	<0·001	6·4	5·3	0·012
Zn (mg)												
Breakfast	5·1	4·1		4·7	2·7		6·6	5·6		5·1	5·3	
Lunch	6·1	5·0		5·0	3·0		5·7	4·3		5·3	4·1	
Dinner	4·3	3·1		4·4	3·8		4·7	4·0		4·7	4·4	
Snack	2·3	1·9	<0·001	3·2	4·0	0·001	2·3	2·0	<0·001	3·7	4·7	0·050

HSES, higher socio-economic status; LSES, lower socio-economic status; RAE, retinol activity equivalents; DFE, dietary folate equivalents.
*P value from repeated-measures ANOVA.

snacks) within subjects. Without class distinction, lunch had higher density of protein ($P < 0.001$) and snacks had higher density of carbohydrates ($P < 0.001$ in HSES boys and girls, $P = 0.034$ in LSES boys, $P = 0.003$ in LSES girls). Mean density of fat was not significantly different between the mealtimes ($P = 0.198$ in HSES boys, $P = 0.206$ in LSES boys, $P = 0.275$ LSES girls), except in HSES girls for which dinner had higher density of fat ($P < 0.001$). Significant differences were observed for all micronutrients examined, except folate in LSES girls ($P = 0.073$). Most micronutrients had higher density at breakfast for most gender and SES subgroups. The exceptions were vitamin C ($P < 0.001$) for which snacks were a major source, riboflavin in LSES girls ($P < 0.001$) for which dinner was a major source, folate in LSES girls ($P = 0.073$) for which no differences were observed between meals and Zn ($P < 0.001$) for which lunch was a major source in boys and LSES girls. Breakfast was a remarkably superior source for vitamin D, Ca and Fe ($P < 0.001$).

Critical nutrient density by mealtime

Meals with a nutrient density below the critical density computed according to RNI values and energy requirements are presented in Table 4. Snacks had a nutrient density below the critical density for most micronutrients examined, with some differences between genders and social class. Breakfast had a nutrient density below the critical density for vitamin D in all gender and SES subgroups. In LSES girls only, the critical density for breakfast was also below the standard for vitamin C and folate. Snacks had critical densities for nearly all micronutrients examined with the sole exception of vitamin C.

Discussion

Guatemala has traditionally been renowned in the nutritional literature for the description and exploration of nutrient deficiencies[18–21]. At the same time, certain aspects of its traditional Guatemalan cuisine have been associated with good health related to blood pressure[22], intestinal function[23] and cardiovascular health[24]. Increasingly in Latin America, a pattern described as 'nutrition transition' has been documented[25–28]. The nutrition transition experience is related to demographic and socio-economic changes, dietary changes, increased obesity rates and sedentary lifestyles. It is characterized by dietary changes such as an increase in dietary fat (mostly saturated fat) and the increased availability and preference for high-fat/high-carbohydrate energy-dense foods. In Latin America, these changes have been occurring quickly and unevenly across socio-economic groups. As a consequence a shift from infectious diseases to chronic diseases has been observed. Companion studies in our population have confirmed the emergence of overweight and obesity in the middle-class of Quetzaltenango[29,30]

and a lower than recommended consumption of fruits and vegetables (G Montenegro-Bethancourt, unpublished results). The opportunity to look more deeply into the dietary pattern, specifically of how nutrients selectively associate with different meals across the day, has been examined here among 449 schoolchildren of both sexes, attending either public or private schools in the most important metropolitan area of the western highlands of Guatemala.

Certain limitations in the design and methodology are recognized. They derive in part from resource limitations and from limited time of access to each school site and to the subjects within each setting. First, the non-response rate was high which might have resulted in selection bias. The low participation rate is largely caused by the limitations of the data collection time frame combined with the necessary informed consent procedures. There were multiple opportunities for a child to be missed during the five consecutive days of recruitment and data collection. 'Forgetting' informed consent forms and leaving data collection booklets at home were common occurrences. While efforts were made to include children with missing data, the time restraints of the data collection period did not permit researchers to return to the same schools. Non-response rate was higher in children of LSES (46 %) compared with children of HSES (35 %). It is, for example, possible that those children with a poor diet may have opted not to participate, or simply that children were disinterested in the extra-curricular activities.

Second, the present study is based on a single day's register of foods and beverages with the disadvantage of not being representative of the habitual nutrient intake of any individual within the group. As a consequence of this limitation, analysis in the study was conducted at the group rather than individual level, as a single 24 h recall better represents the distribution of the group (and subgroups) intake within the season of the year. With only one day, however, we could not adjust the group averages for variance[31] and thus the reported distributions are wider than would be conventionally reported with the opportunity for variance adjustments. However, requesting a second day's registry, even in a sub-sample of our survey population, represents an inconvenience that might have interfered with institutional collaboration or lowered the response rate.

Third, our data rely on self-reporting by children. Paediatric diet researchers have been generally optimistic about the validity of 24 h reporting by children[32–34]. Lytle et al.[34] validated 24 h recalls assisted by food records in third-grade children; they judged prospective pictorial representation as facilitating and this method valid for assessing the dietary intake of children as young as 8 years old for the purpose of group comparison.

Furthermore, the nutritional content of the recipes was determined on the basis of raw ingredients, without considering the losses due to heating treatment during

Table 4 Gender-specific critical densities for micronutrients and meals with average content below critical densities: third- and fourth-grade schoolchildren from Quetzaltenango, Guatemala, 2005

	Critical density (per 4187 kJ/1000 kcal)*	HSES	LSES
Boys (n 217)			
Vitamin A (RAE)	266·7	snacks	
Vitamin C (mg)	18·7		
Vitamin D (μg)	2·7	breakfast, lunch, dinner, snacks	breakfast, lunch, dinner, snacks
Thiamin (mg)	0·5		snacks
Riboflavin (mg)	0·5		
Folate (DFE)	160·0	lunch, dinner, snacks	lunch, dinner, snacks
Ca (mg)	373·3	lunch, snacks	lunch, dinner, snacks
Fe (mg)	4·8	snacks	lunch
Zn (mg)	3·0	snacks	
Girls (n 232)			
Vitamin A (RAE)	303·0	snacks	
Vitamin C (mg)	21·2		breakfast
Vitamin D (μg)	3·0	breakfast, lunch, dinner, snacks	breakfast, lunch, dinner, snacks
Thiamin (mg)	0·5	dinner, snacks	dinner, snacks
Riboflavin (mg)	0·5		snacks
Folate (DFE)	181·8	lunch, dinner, snacks	breakfast, lunch, dinner, snacks
Ca (mg)	424·2	lunch, snacks	lunch, dinner, snacks
Fe (mg)	5·5	snacks	
Zn (mg)	3·4	snacks	

HSES, higher socio-economic status; LSES, lower socio-economic status; RAE, retinol activity equivalents; DFE, dietary folate equivalents.
*Critical density was based on the WHO/FAO vitamin and mineral requirements (Recommended Nutrient Intakes)[16] and a recommended daily energy intake of 7850 kJ (1875 kcal) for boys and 6908 kJ (1650 kcal) for girls[17].

cooking or frying. Thus we could be overestimating the nutritional contribution for the labile vitamins. In addition, there are limitations to the nutrient data obtained from the FCT. Finally, we generally selected our analyses to focus within the daily consumption of nutrients by meals within the various sub-samples of the study, rather than making any systematic effort to identify differences in total consumption or intake adequacy across subgroups.

What was noteworthy in our study was the relative parity for the energy contribution from the various mealtimes across the day of registry. When pooled across social groups (data not shown), the energy contributions from breakfast, dinner and snacks were within a few percentage points of one another (∼23 %), whereas lunch was marginally greater, providing 30 (SD 10) % of daily energy. A parallel lunchtime bulge in relative consumption was seen for protein and carbohydrate, with fat contribution remaining more evenly distributed among the four meals. In contrast, Matthys *et al.*[5] found a lower contribution of snacks to energy distribution among meals in Flemish adolescents. In their sample, breakfast and lunch accounted for 32 % and 31 %, respectively, of the day's energy, whereas snacks contributed only 16 %, with the remaining 21 % coming from the evening meal[5]. Another study in Belgian adolescents found a lower contribution of breakfast to energy distribution (15.7 % for boys and 14.9 % for girls) among meals[35]. Inequality of energy contribution among meals was also the rule in a sample of Swedish adolescents, aged 15 to 16 years, in which the percentage of energy from meals was 20 % and 21 % from breakfast, 16 % and 17 % from lunch, 26 % and 28 % from dinner and 37 % and 35 % from in-between meals in boys and girls, respectively[7]. These are European

studies in slightly older children, but in the absence of analogous approaches applied to Central American or Latin American children, they represent the only basis for meal-pattern comparison for the juvenile situation.

Several studies have focused on breakfast skipping and breakfast quality. Good breakfast quality has been shown to relate to a better overall dietary pattern[3,35]. Irregular breakfast eating is related to negative lifestyle factors such as smoking, a higher percentage of energy from snack foods and lower intake of micronutrients[7], and also mental distress and lower academic performance[36–38]. In our study, children rarely skipped breakfast (<1 %) and breakfast was the largest source of essential micronutrients.

With respect to micronutrient contributions in relation to the meal pattern, an additional contrast is seen between our findings and those of the Flemish series[5]. In these Guatemalan third- and fourth-grade schoolchildren, snacks contribute less to the day's intake of vitamin A, vitamin D, riboflavin, Ca, Fe and Zn than to daily energy. This is similar to the role of snacks' micronutrient contribution in Finnish adults as reported by Ovaskainen *et al.*[8]. By contrast, in the Belgian adolescents, micronutrient intake generally bore a constant relationship to energy intake; there, micronutrient densities were apparently uniform across meals[5].

It is not sufficient, however, simply to know whether there is insufficiency, adequacy or excess of macro- or micronutrients intake from a diet. The meal-based context of nutrients can only be appreciated when dietary intake focuses on a meal-by-meal assessment of macro- and micronutrients as done here and in companion studies. On the practical side, moreover, knowledge of the nutrient distribution can be used by nutritional professionals as a

fulcrum to plan interventions to redress either an excess or a deficiency of a nutrient, using a meal-based perspective in addressing any unhealthful aspect of dietary consumption. In this way, the pattern described would guide the strategy of public health interventions to redress any problems of insufficient or excessive intake of nutrients or dietary constituents. For reducing intake of food components that are associated with poor health, one must know when they are most likely to be eaten. Similarly, to redress deficiencies, one must know which meals are generally rich, or poor, in these nutrients.

The nutrients are consumed in the context of foods and beverages. The selection of foods in Table 1 reflects the preferences of children as well as the cultural norms of the caregivers and the availability, affordability and accessibility of the items in the marketplace. The ten leading items constitute between 68·0 % and 69·5 % of breakfast's energy, between 48·7 % and 59·3 % for lunch, between 47·3 % and 59·8 % for dinner and between 36·3 % and 52·9 % for combined snacking. In general, the ten main sources accounted for slightly more meal energy for the LSES children, reflecting a lesser variety. Notable across genders and social class is the consumption of corn tortilla. It ranks high in energy contribution to both the midday and the evening meals. The Mayan cuisine, of course, is based on maize, as exemplified in the novel *Hombres de Maíz* (*Men of Corn*) by the Guatemalan Nobel Laureate, Miguel Angel Asturias[39]. The Mayan creation myth proclaims that the gods created Man from corn dough. This finding of a corn-rich diet in lower social classes has also been documented in Mexican adolescent girls[40]. Ready-to-eat breakfast cereals were predominant as a breakfast item, ranking consistently higher in the HSES sample than in its less affluent counterpart; this also confirms the finding for Mexican adolescents[40]. Several studies have mentioned the importance of ready-to-eat breakfast cereals in terms of nutritional benefits[3,41,42].

The unbalanced distribution of nutrient intake across mealtimes is subject to rapid change. For instance, the Central American and Dominican Republic Free Trade Agreement came into affect between Guatemala and the USA on 1 June 2006. If schoolchildren's dietary habits evolve under the influence of a broader selection of foods in the marketplace, it could produce major changes from what is currently being eaten at the various meals. To the extent that the nutrient compositions of the new foods are likely to be different, wholesale redistribution of nutrient intake patterns could result. Micronutrients that are currently abundant in the breakfast fare, for instance, may become scarcer.

Latin American public policy has been informed in the past by the concept of critical nutrient density. In a region-wide consensus meeting held by the Cavendas Foundation in Caracas, Venezuela in 1986, an alternative approach to nutrient recommendations, based on nutrient density, was advanced[15]. It proposed that a Latin American family eats as a unit; if all nutrients were adequate for every meal, then all members would simultaneously achieve their specific needs. The nutrient density focus for dietary analysis has grown in interest in recent years[43–45]. The present study informs us is that micronutrient density varies by meal, such that changing the selection patterns for one meal, as with a school meal intervention, could differentially influence the whole day's supply.

Conclusions

The children of both low and high social class of this urban centre in the Guatemalan highlands had remarkably equivalent and balanced distributions of energy across the four daily meal settings. Protein, carbohydrate and the various vitamins and minerals were generally concentrated into one or two of the meals. This produced unique nutrient densities among the meals. To the degree that certain problems of deficient intake, e.g. vitamin D, remain to be redressed, an understanding of how foods and food groups are combined – within meals and across the day – could be useful in designing the appropriate education and inducement for remedy. The present findings, therefore, place a mathematical face on the complexities of juggling a confluent series of public health aims. We agree with the comments of Perez *et al.*[46] that evaluating 'differences in dietary intake and meal patterns by grade can provide readily accessible information to develop a needs assessment or intervention materials for children'. The meal-based approach may provide guidance to strategies to improve dietary balance in an era of coexisting energy overnutrition and micronutrient inadequacy.

data analysis. L.D.J.K. provided statistical advice. C.M.D. and N.W.S. contributed in the design of the study, supervision, interpretation of results and writing of the manuscript. There were no conflicts of interest.

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Appendix

Estimated 1 d intakes of energy, macronutrients and selected micronutrients by mealtime, gender and socio-economic status: third- and fourth-grade schoolchildren from Quetzaltenango, Guatemala, 2005

Absolute daily estimated intake per meal	Boys (n 217)				Girls (n 232)			
	HSES (n 111)		LSES (n 106)		HSES (n 111)		LSES (n 106)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Energy (kJ)								
Breakfast	1771	821	2236	1223	1687	892	1905	871
Lunch	2700	1340	2445	1122	2332	963	2319	1093
Dinner	2022	1239	1922	1122	1892	1202	1997	1126
Snack	1897	1097	1562	1001	2244	1382	1721	1193
Energy (kcal)								
Breakfast	423	196	534	292	403	213	455	208
Lunch	645	320	584	268	557	230	554	261
Dinner	483	296	459	268	452	287	477	269
Snack	453	262	373	239	536	330	411	285
Protein (g)								
Breakfast	14	8	18	11	13	8	15	10
Lunch	27	15	22	14	24	14	20	11
Dinner	18	12	17	13	16	11	16	12
Snack	12	12	8	9	13	10	8	7
Fat (g)								
Breakfast	13	7	15	10	11	7	13	8
Lunch	20	15	16	15	15	9	17	15
Dinner	17	12	14	11	18	17	16	13
Snack	15	11	11	10	16	13	13	13
Carbohydrate (g)								
Breakfast	65	38	83	56	63	38	72	39
Lunch	93	54	92	44	85	47	85	47
Dinner	67	51	70	45	59	39	70	45
Snack	70	39	62	38	87	54	68	46
Vitamin A (RAE)								
Breakfast	311	164	301	175	308	181	294	177
Lunch	322	526	303	717	320	305	269	264
Dinner	231	229	177	148	217	226	194	114
Snack	93	155	108	112	133	146	133	122
Vitamin C (mg)								
Breakfast	31	50	17	34	27	50	8	11
Lunch	36	39	21	27	34	43	33	43
Dinner	11	20	10	19	16	36	13	28
Snack	33	52	11	28	41	54	27	43
Vitamin D (μg)								
Breakfast	1·9	1·0	1·2	1·1	1·6	1·2	0·9	1·0
Lunch	0·3	0·4	0·3	0·5	0·3	0·4	0·2	0·4
Dinner	0·8	1·0	0·4	0·6	0·7	0·8	0·5	0·6
Snack	0·2	0·5	0·2	0·4	0·3	0·6	0·2	0·4

Continued

Absolute daily estimated intake per meal	Boys (*n* 217)				Girls (*n* 232)			
	HSES (*n* 111)		LSES (*n* 106)		HSES (*n* 111)		LSES (*n* 106)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Thiamin (mg)								
Breakfast	0·4	0·3	0·3	0·2	0·4	0·3	0·3	0·4
Lunch	0·3	0·2	0·3	0·2	0·3	0·2	0·3	0·2
Dinner	0·2	0·2	0·3	0·3	0·3	0·3	0·3	0·3
Snack	0·2	0·2	0·1	0·2	0·3	0·3	0·2	0·1
Riboflavin (mg)								
Breakfast	0·9	0·7	1·2	2·0	0·8	0·6	1·2	1·9
Lunch	1·0	1·6	1·2	2·5	0·6	1·4	1·9	3·2
Dinner	0·7	1·3	1·1	2·5	0·6	1·1	1·7	2·9
Snack	0·3	0·3	0·2	0·2	0·3	0·3	0·2	0·2
Folate (DFE)								
Breakfast	97	65	82	68	94	65	51	50
Lunch	79	78	67	60	73	72	68	61
Dinner	55	47	45	49	53	52	49	59
Snack	38	37	30	36	46	51	31	32
Ca (mg)								
Breakfast	356	202	247	206	347	209	253	245
Lunch	159	168	182	189	140	147	180	205
Dinner	244	260	179	258	224	230	176	224
Snack	136	162	102	115	177	185	108	122
Fe (mg)								
Breakfast	6·4	4·8	5·0	4·0	6·1	4·8	4·6	4·2
Lunch	3·7	2·6	2·7	2·0	3·2	2·0	3·1	3·7
Dinner	3·3	2·9	3·1	2·6	3·1	2·5	2·7	2·2
Snack	2·0	1·4	2·3	1·8	2·6	2·3	2·2	1·5
Zn (mg)								
Breakfast	2·3	2·6	2·4	1·9	2·7	2·8	2·7	4·1
Lunch	3·5	2·4	3·0	2·2	3·1	2·4	2·7	2·0
Dinner	2·0	1·7	2·2	3·3	2·1	2·4	2·2	2·3
Snack	1·2	1·1	1·1	1·2	1·4	1·3	1·3	1·3

HSES, higher socio-economic status; LSES, lower socio-economic status; RAE, retinol activity equivalents; DFE, dietary folate equivalents.