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Original Articles

Marina Campos Araujo[I]

Ilana Nogueira Bezerra[I]

Flávia dos Santos Barbosa[II]

Washington Leite Junger[III]

Edna Massae Yokoo[IV]

Rosangela Alves Pereira[V]

Rosely Sichieri[III]

Macronutrient consumption and inadequate micronutrient intake in adults

ABSTRACT

OBJECTIVE: To estimate energy and nutrient intake and prevalence of inadequate micronutrient intake among Brazilian adults.

METHODS: Data from the National Dietary Survey, from the 2008-2009 Household Budget Survey, were used. Food consumption was evaluated through food record on two non-consecutive days. A total of 21,003 individuals (52.5% women), between 20-59 years old, participated in the survey. Usual nutrient intake was estimated according to the National Cancer Institute method. The Estimated Average Requirement (EAR) cut-off points were used to determine the prevalence of inadequate micronutrient intake. For manganese and potassium, the Adequate Intake (AI) was used as cut-off. Sodium intake was compared with the Tolerable Upper Intake Level (UL). The probability approach was used to determine the prevalence of inadequate iron intake. The data were analyzed according to the location of the household (urban or rural) and macro regions of Brazil.

RESULTS: The mean energy intake was 2,083 kcal among men and 1,698 kcal among women. Prevalence of inadequacy equal to or greater than 70% were observed for calcium among men and magnesium, vitamin A, and sodium among both men and women. Prevalence equal to or greater than 90% were found for calcium in women and vitamins D and E in both genders. Prevalence lower than 5% were found for iron in men and for niacin in men and women. In general, prevalence of inadequate intake was higher in the rural area and in the Northeast region.

CONCLUSIONS: Energy intake was higher among individuals who live in urban areas and in the North region. The greatest risk groups of inadequate micronutrient intake were women and those living in rural areas and in the Northeast region.

DESCRIPTORS: Adult. Food Habits. Dietary Carbohydrates. Dietary Proteins. Dietary Fats. Micronutrients, deficiency. Nutrition Assessment. Diet Surveys, utilization.

I Programa de Pós-Graduação em Saúde Coletiva. Departamento de Epidemiologia. Instituto de Medicina Social. Universidade do Estado do Rio de Janeiro. Rio de Janeiro, RJ, Brasil

II Departamento de Nutrição Social. Instituto de Nutrição. Universidade do Estado do Rio de Janeiro. Rio de Janeiro, RJ, Brasil

III Departamento de Epidemiologia. Instituto de Medicina Social. Universidade do Estado do Rio de Janeiro. Rio de Janeiro, RJ, Brasil

IV Departamento de Epidemiologia e Bioestatística. Instituto de Saúde da Comunidade. Universidade Federal Fluminense. Niterói, RJ, Brasil

V Departamento de Nutrição Social Aplicada. Instituto de Nutrição Josué de Castro. Universidade Federal do Rio de Janeiro. Rio de Janeiro, RJ, Brasil

Correspondence:
Marina Campos Araujo
Instituto de Medicina Social – UERJ
Rua São Francisco Xavier 524, 7º andar Sala E7002 Maracanã
20550-900 Rio de Janeiro, RJ, Brasil
E-mail: mcamposaraujo@gmail.com

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INTRODUCTION

Assessing dietary intake is essential for guiding public policies in preventing both diseases resulting from deficiencies and chronic non-communicable diseases (NCD). In spite of this, Brazil did not have a regular nationwide survey evaluating individual food intake,[24] the only example being the National Study on Household Expenditure (Endef), carried out in 1970, which used the direct weighing of food to estimate dietary intake of Brazilian families.[a]

Combining the findings of national studies on nutritional deficiencies[b] with those on excess weight,[c] it can be stated that Brazil faces a double burden of diseases originating in diet. Diseases caused by deficiency of specific micronutrients have been verified; for example, the prevalence of anemia in children and non-pregnant women varies between 21% and 29% respectively and inadequate serum levels of vitamin A vary between 17% and 12% respectively.[b] Moreover, results of localized studies registered persistent iron deficiency anemia in pre-school children in Ilha Bela (São Paulo, Southeastern Brazil),[4] outbreaks of beriberi in Maranhão[19] and inadequate vitamin A,[20,28] C,[1,28] E[25,28] and B12[26] intake. What is more, documented levels of obesity among Brazilians are high and increasing.[c]

Micronutrients play an important role in preventing diseases which have significant impact in Brazil. For example, the anti-oxidant action of some vitamins can reduce the occurrence of NCD,[3] excessive sodium intake is associated with high blood pressure and the consequent increased risk of cardiovascular and renal disease[13] and vitamin D and calcium are also essential for healthy bones and reducing the risk of osteoperosis.[14]

The need and relevance of investigating food intake at a national level has been recognized and the most recent Household Budget Survey (POF), conducted in 2008-2009, included a module evaluating individual food intake in a representative sample of the Brazilian population, the National Dietary Survey.[d]

The aim of this study was to estimate energy and nutrient intake and the prevalence of inadequate micronutrient intake in Brazilian adults.

METHODS

Data from the National Dietary Survey, part of the Household Budget Survey, 2008-2009, conducted by IBGE (Brazilian Institute of Geography and Statistics) were analyzed. Details on the sample and the data collection have been published by the IBGE.[d]

POF 2008-2009 used a two-stage cluster sampling design. In the first stage, census tracts were primary sampling units (PSU), which had been previously stratified according to location and mean income of the heads of households, were selected. The PSU were randomly selected with probability proportional to the number of households based on the 2000 Demographic Census. In the second stage, the sample units were permanent private households, selected using simple random sampling without replacement, from within PSU. All of the strata in the study were evaluated throughout the 12 months of the survey.[d]

In the 2008-2009 POF, 68,373 households were selected. A subsample for the INA was calculated at 25% of the households in the POF 2008-2009 sample and was organized so that one in every four households in each PSU was selected. In the data collection stage 16,764 households (24.5%) were sampled. There were 38,340 residents aged ten and over, in 13,569 households, who responded to the research, with a non-response rate of 19%. A total of 34,032 individuals completed the data on food and/or drink intake (11% non-response rate).

This analysis included all adult individuals aged between 20 and 59 years old, excluding pregnant and breastfeeding women (n = 1,065), totaling 21,003 individuals.

Food intake from food records on two non-consecutive days was estimated, in which individuals reported all food and drink consumed on the day in question, also recording the time, quantity in portion sizes, method of preparation as well as the source of the food (at home or away from home). There was also a question about sugar and/or sweetener consumption. When the subject was unable to complete the food record this could be done with the help of another member of the household or another nominated person.

Data entry took place in the subjects' home and a data entry program specially designed for recording food intake was used. This program contained approximately 1,500 items (food and drink), selected from the 5,686 items registered in the food and drink database from the POF 2002-2003. This program also included codes for recording the method of preparation (14 methods of preparation) and the measurement unit used to record

[a] Instituto Brasileiro de Geografia e Estatística. Estudo Nacional da Despesa Familiar – dados preliminares. Brasília (DF); 1978.
[b] Ministério da Saúde. Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher – PNDS 2006: dimensões do processo reprodutivo e da saúde da criança. Brasília (DF); 2009.
[c] Instituto Brasileiro de Geografia e Estatística. Pesquisa de Orçamentos Familiares, 2008-2009. Antropometria e estado nutricional de crianças, adolescentes e adultos no Brasil. Rio de Janeiro; 2010.
[d] Instituto Brasileiro de Geografia e Estatística. Pesquisa de orçamentos familiares, 2008-2009. Análise do consumo alimentar pessoal no Brasil. Rio de Janeiro; 2011.

the quantity consumed (106 portion sizes). At the end of the research, 1,120 food/drink items had been reported.

Partial analyses were carried out during data collection to control the quality.[d]

When verifying the reliability of the data, 29 individuals reporting fewer than five items whose energy consumption seemed unlikely were excluded. In addition, quantities considered to be unlikely were entered using the hot deck imputation procedure and this information was registered in the database.[d]

The addition of soya oil to all meat, fish and poultry dishes and to boiled and sautéed vegetables was taken into account. Moreover, the addition of 10 g of sugar (standardized) to every 100 ml of fruit juice, coffee, coffee and milk, tea and mate was taken into account when the subject reported using sugar as usual and 5 g of sugar for every 100 ml when the subject reported using both sugar and sweetener.

In order to estimate energy intake and macro- and micronutrient intake, tables of nutritional composition[e] and portion sizes[f] compiled specifically for analyzing the food items and dishes reported in the 2008-2009 POF were used. Data on nutrient intake represented only that from food and drink and did not include supplements and/or medicines.

The method used to estimate the mean and the distribution percentiles of usual nutrient intake from food was developed by the National Cancer Institute (NCI). The NCI method enables usual intake of food items consumed daily by the majority of individuals to be estimated, which is the case for many nutrients, as well as for less frequently consumed foods. In the case of frequently consumed foods and nutrients, the method takes into account only the quantities consumed on a specific day using the data described in the food records.[27]

In order to estimate usual intake of the variables which represent ratios: percentage of calories from protein, carbohydrates and lipids, an extension of the NCI method, based on a bivariate model, is used.[5]

The estimates of standard errors obtained using the NCI method are based on assumptions of the observations' independence and equal distribution, i.e., the assumption that a simple random sample is being used. Such assumptions do not apply to the data obtained in a complex sample such as the POF. Thus, the standard errors were estimated using the balanced repeated replication technique, with Fay's modification (1989).[15,g]

The prevalence of inadequate micronutrient intake were estimated according to sex and age group, using the Estimated Average Requirements (EAR), as set by the Institute of Medicine (IOM) for the population of the United States and Canada[8-10,12,14] as cutoff points. The EAR represents mean necessity of the nutrient according to gender and stage of life. The prevalence of inadequate intake of each micronutrient was estimated by the proportion of individuals with intake below the EAR value.

The EAR can only be used to estimate prevalence of inadequate intake in the following conditions: (a) distribution of nutrient intake is independent of the requirement distribution; (b) symmetry of distribution in the nutrient requirement; and (c) lower variance in the distribution of nutrient requirement compared to the nutrient intake distribution. Thus, it is necessary to know the distribution of usual intake in the population studied and the EAR for this method works.[11]

Because the distribution of iron requirement among women of reproductive age is skewed, the EAR cut-off point method could not be used;[11] therefore, inadequate iron intake was calculated using a probabilistic approach.[12] To begin with, the 1st, 5th, 10th, 15th, 25th, 40th, 50th, 75th, 85th, 90th, 95th and 99th percentiles of usual iron intake were estimated. Probability of inadequate intake was associated to each percentile. These inadequacy probabilities are specified to each interval of requirement intake of iron according to gender and age group as recommended by the IOM[12] (2001). The prevalence of inadequate iron intake corresponds to the sum of the percentage of individuals with inadequate intake in each percentile.

For those nutrient for which an EAR has not been established, such as manganese[12] and potassium,[13] mean intake were compared to values of adequate intake (AI), as it was not possible to estimate prevalence of inadequate intake.

As sodium intake in Brazil is excessively high,[23] in order to calculate excessive sodium intake, values above the Tolerable Upper Intake Level (UL) were considered.[13] The sodium assessed included both the intrinsic to food items and the salt added to it.

Prevalence of inadequate intake were estimate according to regions (North, Northeast, Southeast, South and Midwest) and location of the households (urban or rural). When the cutoff points varied according to age group for the same nutrient, the weighted mean of the prevalence of inadequate intake was calculated.

[e] Instituto Brasileiro de Geografia e Estatística. Pesquisa de orçamentos familiares, 2008-2009. Tabela de composição nutricional dos alimentos consumidos no Brasil. Rio de Janeiro; 2011.
[f] Instituto Brasileiro de Geografia e Estatística. Pesquisa de orçamentos familiares, 2008-2009. Tabela de medidas referidas para os alimentos consumidos no Brasil. Rio de Janeiro; 2011.
[g] Fay RE. Theory and application of replicate weighting for variance calculations. In: Proceedings of the Survey Research Methods Section. Washington, United States. Washington (DC): American Statistics Association; 1989. p. 212-7.

All of the estimates were calculated using Statistical Analysis System (SAS), version 9.1 software, taking into account expansion factors in the POF 2008-2009 and the complexity of the sample design.

The research protocol was approved by the Ethics Committee of the Instituto de Medicina Social of the Universidade do Estado do Rio de Janeiro (CAAE 0011.0.259.000-11).

RESULTS

The mean age of the adults studied was 37 years old (standard error [SE] = 0.13) and 52.5% were female. The highest mean of energy intake was observed among men and among individuals in the urban area. The North region had the highest mean energy intake, whereas the lowest for both men and women was in the Midwest region. From the point of view of diet quality, men consumed slightly more calories from protein than women; on the other hand, women reported more energy from carbohydrates. Energy from lipids was similar for both sexes (Table 1).

The highest rate of inadequate intake, for both men and women, were for vitamins E and D and calcium, and for excessive sodium intake. Excessive sodium intake was found in 89.3% of men and 70% of women, and the highest levels of inadequate calcium intake were among women aged 51 to 59 (96.4%). The prevalence of inadequate intake of magnesium and vitamin A was greater than 70% for all groups studied (Table 2).

For both genders, the prevalence of inadequate micronutrient intake was more accentuated in rural areas than in urban areas, with the exception of magnesium and vitamin D and excessive sodium intake. The inadequacy of the phosphorous and iron intake among women in rural area was three to five times higher, respectively, compared to inadequacy among men in the same area. It was also observed that in urban area inadequate iron intake was seven times higher in women than in men (Figure 1).

When the analysis was stratified according to regions of the country, for both sexes, it was observed that the South was notable for inadequate magnesium intake, whereas the Northeast showed higher prevalence of inadequate zinc and iron, the latter especially among women (Figure 2).

Moreover, the South had the highest levels of inadequate vitamin D intake for both sexes, and the Northeast and Midwest stood out for higher levels of inadequate thiamin intake. Lower rates of inadequate vitamin B12 intake were observed in the North and Midwest. The

Table 1. Mean and standard error (SE) of energy intake and percentage of energy provided by macronutrients according to sex, location of household and region of the country. Brazil, 2008-2009.

	Male															
	Brazil		Location of household				Regions									
			Urban		Rural		North		Northeast		Southeast		South		Midwest	
	(n = 9,974)		(n = 7,441)		(n = 2,533)		(n = 1,593)		(n = 3,501)		(n = 2,191)		(n = 1,298)		(n = 1,391)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Energy (kcal)	2,083	12	2,009	10	1,742	9	2,222	18	2,144	15	2,070	14	1,994	10	1,920	10
Protein (% kcal)	17.4	0.1	17.2	0.1	18.3	0.1	17.6	0.2	17.3	0.1	16.6	0.1	15.9	0.1	17.0	0.2
Carbohydrate (% kcal)	54.4	0.3	54.2	0.3	55.3	0.2	53.7	0.4	55.3	0.2	54.2	0.5	54.5	0.3	52.7	0.2
Lipids (% kcal)	27.3	0.1	27.7	0.1	25.3	0.4	25.4	0.3	25.6	0.1	28.1	0.1	28.6	0.3	28.4	0.4
	Female															
	Brazil		Location of household				Regions									
			Urban		Rural		North		Northeast		Southeast		South		Midwest	
	(n = 11,029)		(n = 8,757)		(n = 2,272)		(n = 1,579)		(n = 4,015)		(n = 2,442)		(n = 1,390)		(n = 1,603)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Energy (kcal)	1,698	7	1,873	6	1,620	11	1,850	9	1,784	7	1,712	7	1,652	10	1,586	8
Protein (% kcal)	16.8	0.1	16.7	0.1	17.5	0.2	17.7	0.2	17.3	0.1	16.7	0.1	15.9	0.1	17.0	0.2
Carbohydrate (% kcal)	55.8	0.2	55.7	0.2	56.5	0.3	55.5	0.4	56.1	0.2	55.5	0.2	56.7	0.3	55.6	0.3
Lipids (% kcal)	27.4	0.1	27.7	0.1	25.7	0.3	26.0	0.6	26.2	0.6	28.1	0.2	28.3	0.5	27.5	0.3

Table 2. Reference intake, mean, percentiles of usual intake distribution and prevalence of inadequate micronutrients intake according to sex. Brazil, 2008-2009.

Nutrients	Reference	Mean	Percentiles of usual nutrients intake					Prevalence of inadequate intake (%)
			10	25	50	75	90	
Male (n = 9,974)								
Estimated Average Requirement								
Calcium (mg)	800	550	253	353	499	691	911	84.0
Magnesium (mg)	330 (20-30 years)	282	162	208	269	342	420	71.5
	350 (31-59 years)	278	159	204	264	337	413	78.4
Phosphorous (mg)	580	1,102	639	809	1,043	1,330	1,640	6.5
Iron (mg)	6,0	13.6	7.8	10.0	13.1	16.6	20.3	4.1*
Copper (mg)	0,7	1.3	0.7	0.9	1.2	1.6	2.1	12.0
Zinc (mg)	9,4	13.2	7.5	9.6	12.5	16.0	19.7	23.4
Selenium (mcg)	45	100	51	68	93	124	159	6.2
Thiamine (mg)	1,0	1.3	0.7	0.9	1.2	1.6	2.0	30.8
Riboflavin (mg)	1,1	1.7	1.0	1.2	1.6	2.1	2.7	16.9
Niacin[a] (mg)	12	30.3	17.1	22.0	28.7	36.8	45.5	2.0
Pyridoxine (mg)	1,1 (20-50 years)	1.7	0.9	1.2	1.6	2.1	2.6	17.5
	1,4 (51-59 years)	1.6	0.9	1.1	1.5	1.9	2.4	43.9
Vitamin B12 (mcg)	2,0	5.4	2.1	3.1	4.7	6.9	9.5	8.5
Vitamin A[b] (mcg)	625	446	140	226	370	581	847	78.5
Vitamin C (mg)	75	131.7	9.8	27.7	72.5	165.3	318.7	51.0
Vitamin D (Calciferol) (mcg)	10	3.3	1.1	1.8	2.8	4.3	6.1	98.6
Vitamin E[c] (mg)	12	4.8	2.7	3.5	4.6	5.9	7.3	99.9
Adequate Intake								
Manganese (mg)	2.3	4.0	1.2	1.9	3.1	5.1	7.9	-
Potassium (mg)	4,700	2,697	1,578	2,020	2,597	3,264	3,947	-
Tolerable Upper Intake Level								
Sodium (mg)	2,300	3,674	2,265	2,826	3,553	4,390	5,245	89.3
Female (n = 11,029)								
Estimated Average Requirement								
Calcium (mg)	800 (20-50 years)	477	222	309	435	600	786	90.7
	1,000 (51-59 years)	487	228	316	443	613	805	96.4
Magnesium (mg)	255 (20-30 years)	216	129	162	206	258	314	73.7
	265 (31-59 years)	214	128	161	204	256	312	78.1
Phosphorous (mg)	580	876	523	655	832	1,049	1,284	15.7
Iron (mg)	8.1 (20-50 years)	10.2	5.9	7.6	9.8	12.4	15.1	31.5*
	5.0 (51-59 years)	9.5	5.4	7.0	9.0	11.6	14.2	8.9*
Copper (mg)	0.7	1.0	0.5	0.7	0.9	1.3	1.7	25.7
Zinc (mg)	6,8	10.0	5.8	7.4	9.5	12.0	14.8	18.7
Selenium (mcg)	45	77	42	54	72	94	118	13.5
Thiamine (mg)	0,9	1.1	0.6	0.8	1.0	1.3	1.6	37.6
Riboflavin (mg)	0,9	1.5	0.9	1.1	1.4	1.8	2.2	11.3
Niacin[a] (mg)	11	23.7	14.1	17.8	22.6	28.4	34.5	2.9
Pyridoxine (mg)	1,1 (20-50 anos)	1.4	0.8	1.0	1.3	1.6	2.0	31.9
	1,3 (51-59 anos)	1.3	0.8	1.0	1.3	1.6	1.9	53.4
Vitamin B12 (mcg)	2,0	4.2	1.8	2.6	3.8	5.3	7.2	12.6
Vitamin A[b] (mcg)	500	431	149	231	364	557	795	69.2
Vitamin C (mg)	60	127.9	14.2	34.4	79.2	164.6	296.2	40.6
Vitamin D (Calciferol) (mcg)	10	2.8	1.0	1.6	2.4	3.6	5.1	99.6

Continue

Table 2. Continuation.

Nutrients	Reference	Mean	Percentiles of usual nutrients intake					Prevalence of inadequate intake (%)
			10	25	50	75	90	
Vitamin E[c] (mg)	12	3.8	2.2	2.8	3.6	4.6	5.6	100.0
Adequate Intake								
Manganese (mg)	1.8	3.3	0.9	1.5	2.5	4.2	6.6	-
Potassium (mg)	4,700	2,154	1,309	1,646	2,079	2,581	3,093	-
Tolerable Upper Intake Level								
Sodium (mg)	2,300	2,815	1,776	2,188	2,720	3,339	3,976	70.0

[a] Niacin equivalents
[b] Retinol activity equivalents
[c] Total alpha-tocopherol
*Inadequate iron intake was calculated using the probabilistic approach.

greatest discrepancy between regions was observed in vitamin B12 intake among women, with the prevalence of inadequate intake in women 4.3 times higher in the Southeast than in the North. The inadequate vitamin C intake among men was greater in the Southeast and the inadequacy of riboflavin intake was high in the Midwest (Figure 3).

Despite the impossibility of estimating the inadequacy of manganese and potassium intake, it was observed that approximately 34.4% and 97% of men, respectively, had intakes below the reference value. Among women, the percentage of intake below the reference value was 33.5% for manganese and 99.7% for potassium. Similar results were observed regarding the location of the household. Considering the regions, the percentage of individuals below the reference value for manganese varied from 23% in the South to 48% in the North, for both sexes. The quantity of individuals with potassium intake below the reference values varied between 94% (North) and 97% (Northeast, Southeast and South) for men and, for women, these percentages were higher, approaching 100% (data not shown).

DISCUSSION

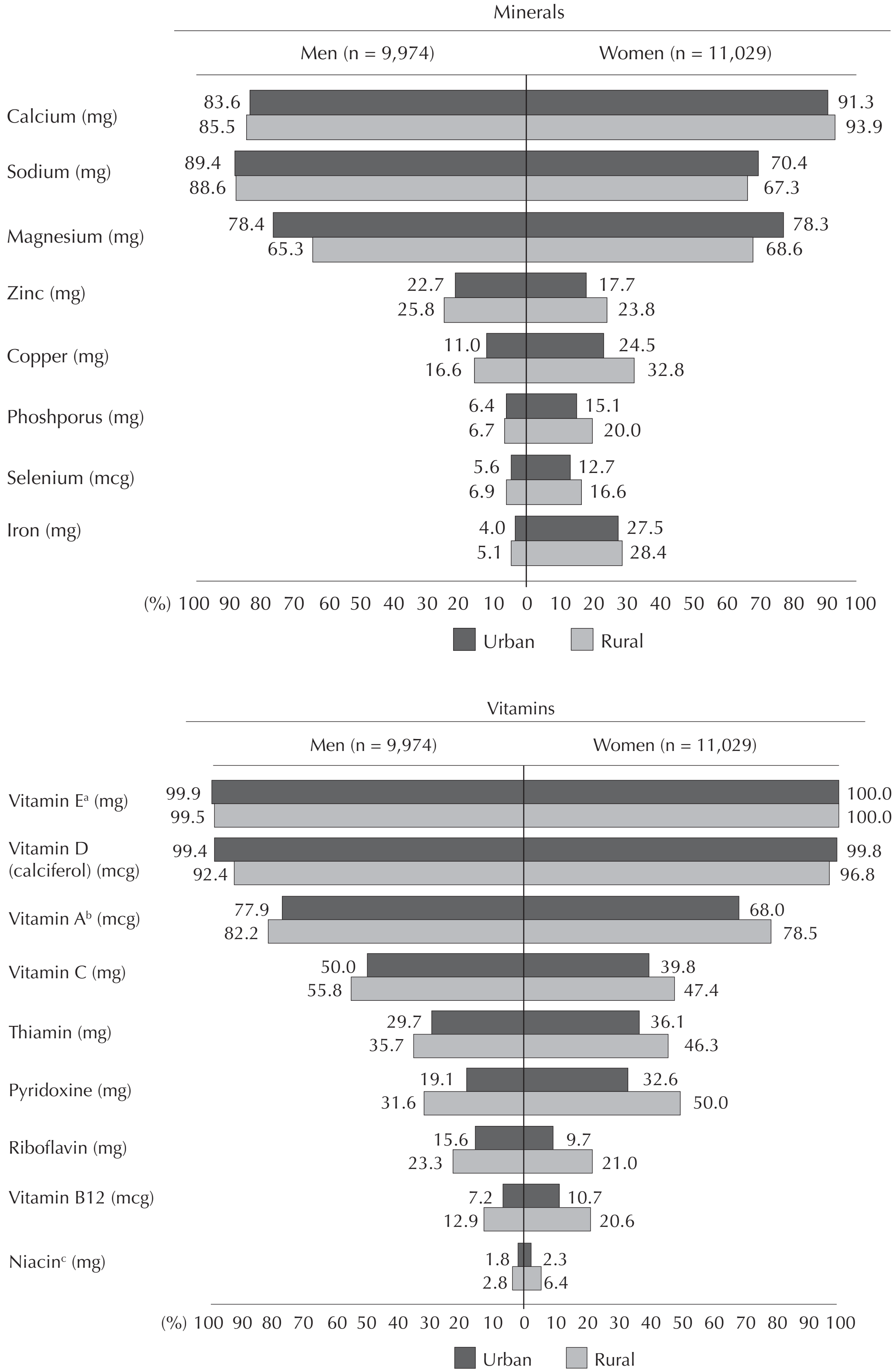
In the first characterization of micronutrient intake in the adult Brazilian population, based on representative sample, we observed a high prevalence of inadequate intake of calcium, magnesium, vitamins E, D, A and C and excessive sodium intake in all regions, in both urban and rural areas.

The greatest difference observed between the sexes was in the prevalence of inadequate iron intake. Women's higher requirements and the fact that men reported consuming more iron rich foods, such as red meat and legumes,[d] explain these marked differences.

When analyzed according to regions and locations of the households, it was verified that, in rural areas, the rates of inadequate intake were almost 50% higher than those in urban areas for both sexes for pyridoxine, riboflavin, vitamin B12 and niacin and also for copper in men. In the rural areas, mean per capita daily intake of "traditional" Brazilian foods such as rice and beans was higher, whereas urban areas were notable for higher consumption of meat, poultry and meat derivatives, as well as processed food and ready to eat meals.[d] Moreover, energy intake in urban areas was 15% higher compared to rural areas, which may explain the higher rates of inadequate nutrient intake observed in rural areas. In Mexico, Barquera et al[2] (2009) also observed higher risk of inadequate intake in adults in rural areas.

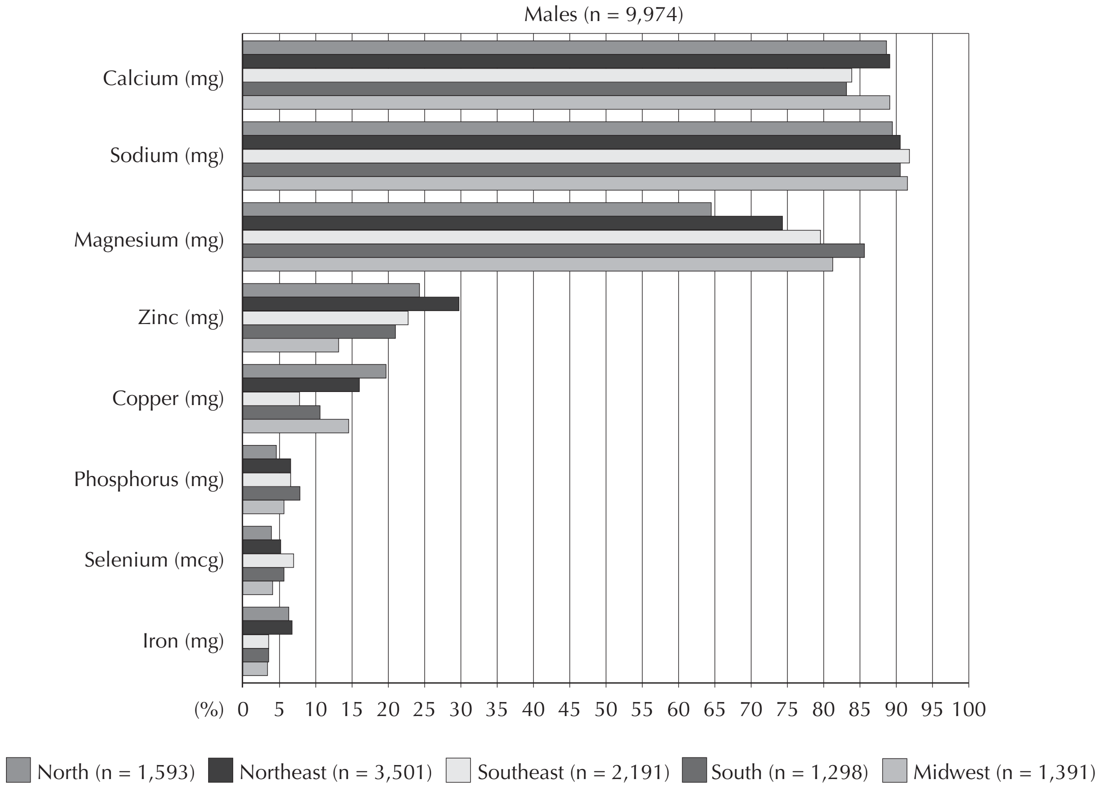
Inadequate intake rates in the different regions of the country show the same trends as the overall national scenario. However, discrepancies between regions were observed for some nutrients, the greatest of these being for vitamin B12: inadequate intake among men in the Northeast and among women in the Southeast was around 75% higher than that observed among women and men in the North. The highest consumption of foods rich in this vitamin, such as fish, was observed in the North. This consumption was three times higher in the North than in the Northeast and almost eight times higher than in the Southeast.[d]

Vitamin D deficiency has been associated with exacerbating osteoporosis in adults and increased risk of death from cancer, cardiovascular disease and diabetes.[7] However, it is known that the simplest way of obtaining the necessary quantity of vitamin D is moderate exposure to sunlight. Exposing the face, arms and hands or arms and legs to the sun for five to ten minutes, twice to three times per week is sufficient to not only to fulfill requirements but to build up a sufficient stock of vitamin D in periods when exposure to the sun is impossible.[6] The EAR for vitamin D was set taking into account the American population's exposure to the sun, which is lower than in Brazil; therefore, the Brazilian population's requirement for vitamin D may be overestimated.[14]



[a] Total alpha-tocopherol
[b] Retinol activity equivalents
[c] Niacin equivalents

Figure 1. Prevalence of inadequate micronutrients intake according to sex and location of household. Brazil, 2008-2009.



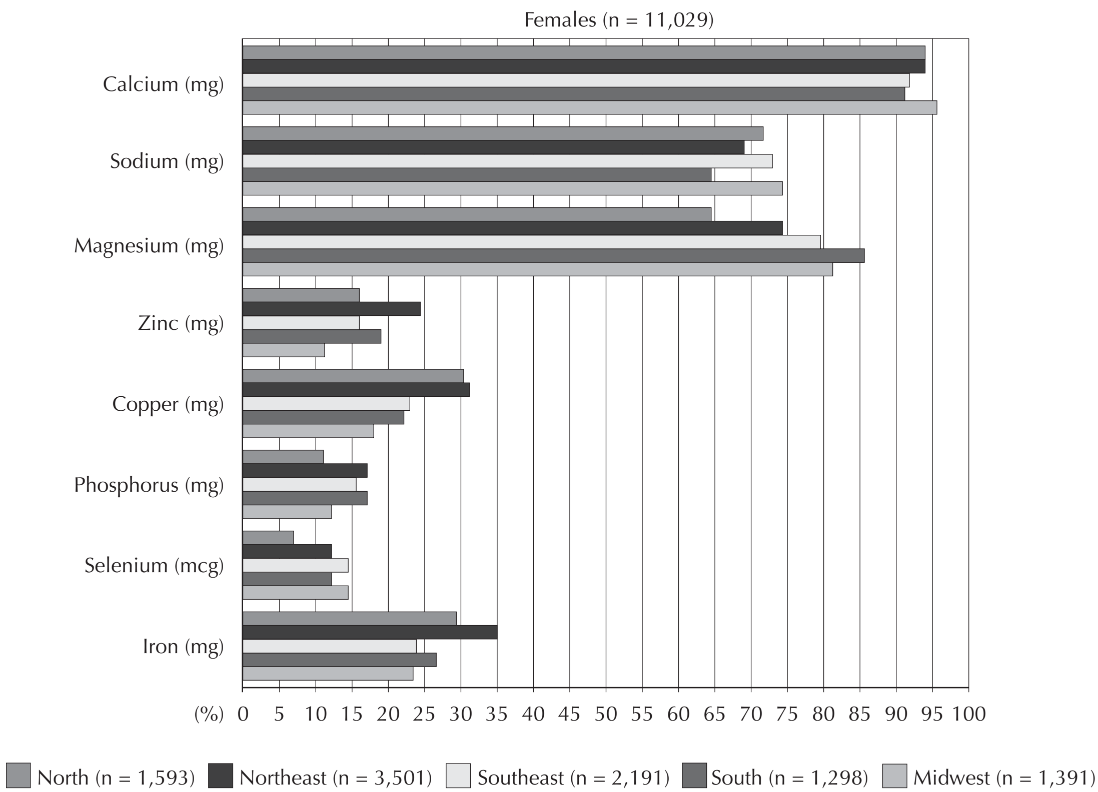
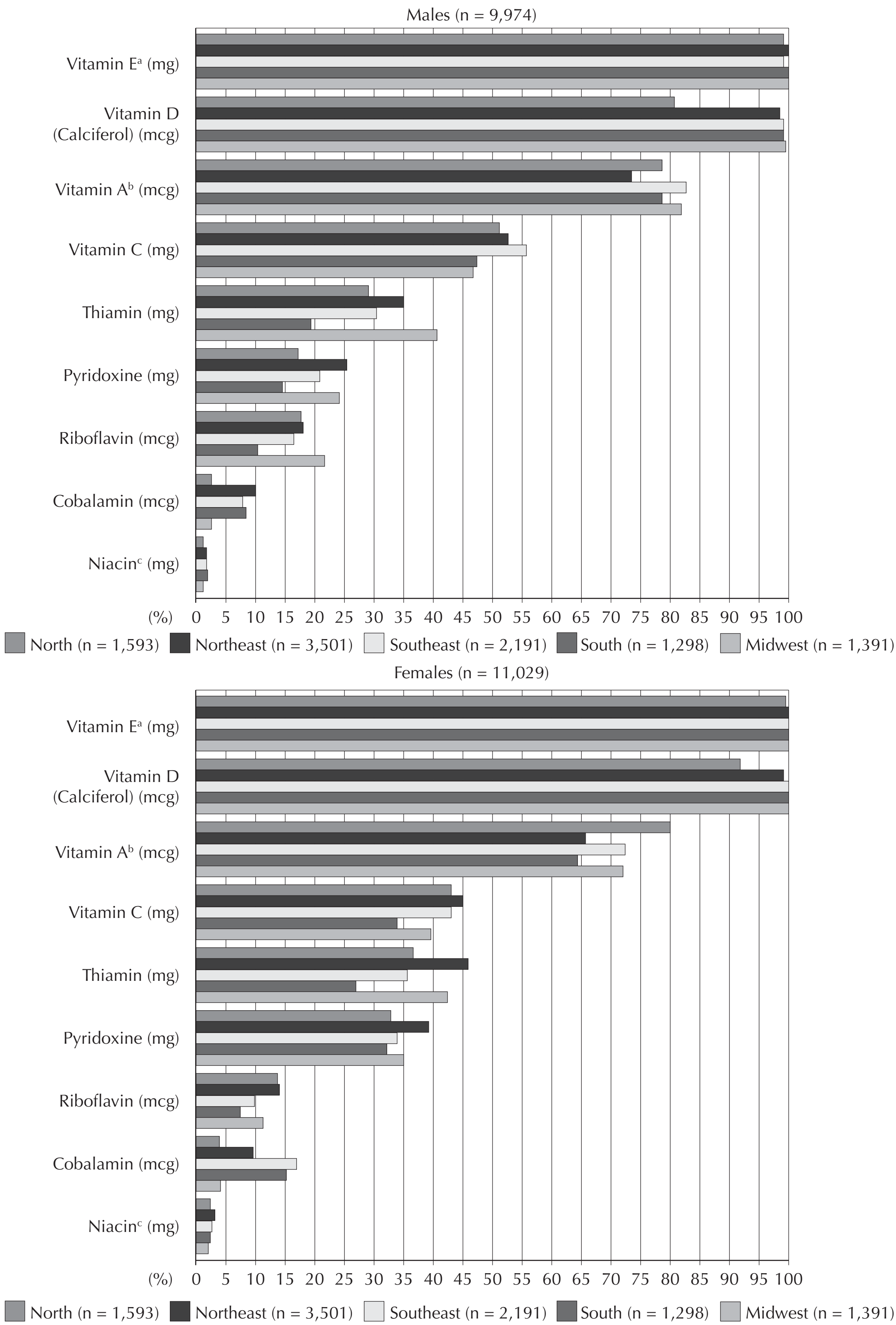


Figure 2. Prevalence of inadequate minerals intake according to sex and region of the country. Brazil, 2008-2009.



[a] Total alpha-tocopherol
[b] Retinol activity equivalent
[c] Niacin equivalent

Figure 3. Prevalence of inadequate vitamins intake according to sex and region of the country. Brazil, 2008-2009.

Almost all of the individuals studied showed inadequate intake of vitamin E due to low levels consumption of nuts such as Brazilian nuts, peanuts, hazelnuts and almonds. The high inadequacy of vitamin A intake are also related to insufficient consumption of offals, yams, carrots, sweet potatoes and broccoli.[d]

As expected, men consumed almost 23% more calories than women, irrespective of region or location of residence. Individuals living in urban areas and in the North region consumed approximately 15% and 16% more calories than those living in rural areas and in the Midwest region, respectively. Brazilian men, on average, consumed around 30% less energy than American men, and Brazilian women, on average, 10% less than their American counterparts.[h] However, underestimation of intake in the American study was around 11%[17] and 17% in the Brazilian study.[d] On the other hand, energy intake in Brazilian men and women was around 6% and 10% higher, respectively, than that registered in Mexico[2] and in the United Kingdom.[29]

Protein's contribution to total calorie intake was similar in Brazil, the United States[h] and the United Kingdom.[29] However, the proportion of lipids was higher in the United States[h] and the United Kingdom[29] and the proportion of carbohydrates was higher in Brazil than in these two countries. The Mexicans consumed fewer calories derived from protein and more deriving from carbohydrates compared to the Brazilians.[2]

With regards to nutrients with high rates of inadequate intake, the data presented are comparable those described for North American adults.[i] However, the magnitude of the inadequacy in Brazil was greater, for example, inadequate intake levels of vitamins E, A and C in Brazilian men were approximately 100%, 78% and 51%, whereas for American adult males they were 90%, 55% and 40% respectively.[i] Moreover, average intake of vitamins and minerals observed in American adults were higher than those estimated among Brazilians. Calcium and vitamin E intake were almost double among Americans compared to Brazilian men.[h]

Two other international population based studies with adults observed -prevalence of inadequate intake lower than those observed in Brazil. A Mexican study carried out in 2006 observed risk of inadequate vitamin A of 31.6% and 22.6% for men and women respectively; 25.6% and 18.4% for vitamin C; 17.2% and 23.5% for calcium; 12.8% and 8.6% for zinc; and 0.3% and 3.7% for iron.[2] An investigation carried out in 2008-2009 in adults in the United Kingdom verified median intakes of calcium, magnesium, thiamin, vitamin B12, vitamin A and potassium above the medians observed among adults in Brazil. However, median intake of iron, zinc, riboflavin and vitamin C and E were similar to those found among Brazilian adults.[29]

No individuals were excluded from this study for energy intake deemed unlikely. The inclusion of individuals who under-report energy intake could overestimate by up to 17% the prevalence of inadequacy.[16] According to Poslusna et al (2009), 30% of underestimated iron, calcium or vitamin C intake may be related to under reporting.[21]

On the other hand, the estimates of usual intake in the present study were based on appropriate statistical methods, adjusting distribution by intra-individual variability which removed extremes considered to be unlikely, for both over- and under-estimates of intake.[18] The study design used allows estimation of population dietary consumption over a year, capturing seasonal variations in Brazilian's eating habits.

The nutritional deficiencies observed were not a result of insufficient quantities of food, as the main indicator of energy deficiency, Body Mass Index (BMI) shows that only 2.7% of adult individuals were classes as underweight.[c] In fact, the results indicate a low density of nutrients in food consumed. High levels of vitamin and mineral inadequacies may be corrected by improving the quality of the diet, including a higher proportion of cereals, legumes, fruit, vegetables, milk and dairy products and reducing the amount of highly processed food. It was verified that mean per capita consumption of milk, milk based drinks and other milk derivatives did not exceed 100 g/ml per day, which explains the high levels if inadequate calcium intake. It was also observed that more than 90% of the Brazilian population consumed fewer fruit and vegetables that recommended, which also explains the high levels of inadequate vitamin C and magnesium intake and the large percentage of individuals with low potassium intake. In addition, processed foods have shown increasing participation of the Brazilian diet, which explains why more than 70% of adults have a sodium intake above the tolerable limit.[d]

The markedly inadequate intake of various micronutrients in adult Brazilians' diets indicates that fortifying food is not the best way to solve this problem and indeed may aggravate it, as has been observed in the Canadian population, in which fortifying food with vitamins and minerals discouraged the adoption of healthy eating habits.[22]

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[h] United States. Department of Agriculture. Agricultural Research Service. Nutrient Intakes from Food: mean amounts consumed per individual, by gender and age. What we eat in American. NHANES 2007-2008. Washington, United States. Washington (DC); 2010. Available from: www.ars.usda.gov/ba/bhnrc/fsrg

[i] Moshfegh A, Goldman J, Cleveland L. What we eat in America. NHANES 2001-2002: Usual nutrient intakes from food compared to dietary reference intakes. 2005. Washington, United States. Washington (DC): United States. Department of Agriculture; 2005.

The present study identified that individuals living in urban areas and in the North region had higher energy intake. Important inadequate micronutrients intake were verified among Brazilian adults, with those most at risk being women and individuals living in rural areas and in the Northeast region.

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