Energy and nutrient intake in Mexican children 1 to 4 years old. Results from the Mexican National Health and Nutrition Survey 2006

Verónica Mundo-Rosas, MSc,(1) Sonia Rodríguez-Ramírez MSc,(1) Teresa Shamah-Levy, MSc.(1)

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Abstract

Objective. To document the energy and nutrient intake of Mexican preschool children using data from the Mexican National Health and Nutrition Survey 2006 (ENSANUT 2006). **Material and Methods**. Dietary data from 3 552 children less than 5 years old collected through a semi-quantitative food frequency questionnaire were analyzed. Energy and nutrient daily intakes and adequacies were calculated. Comparisons were made by geographic region, residence locality, and socioeconomic status. **Results**. The Mexico City region showed the highest energy (103.2%), carbohydrate (109.9%), and fat (110.1%) adequacies. The highest proportion of preschoolers with energy and micronutrients inadequacy (adequacy < 100%) was observed in children of indigenous ethnicity, low socioeconomic status, living in rural localities, and in the south region. **Conclusions**. This information may help as an indicator of food availability and access in different population strata and as a tool to focus interventions on those who may better benefit from food assistance programs.

Key words: diet; nutrients; children; Mexico

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Consumo de energía y nutrimentos en niños mexicanos de 1 a 4 años de edad. Resultados de la Encuesta Nacional de Salud y Nutrición 2006.
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Resumen

Objetivo. Documentar el consumo de energía y nutrimentos en niños mexicanos menores de cinco años, a partir de datos de la Encuesta Nacional de Salud y Nutrición 2006 (ENSANUT 2006), realizada en México en 2006. **Material y métodos**. Se analizó información de un cuestionario semicuantitativo de frecuencia de consumo de alimentos de 3 552 niños. Se calcularon consumos y adecuaciones diarias de energía y nutrimentos, comparando por región geográfica, tipo de localidad y nivel socioeconómico. **Resultados**. La región Ciudad de México presentó la adecuación más alta de energía (103.2%), carbohidratos (109.9%) y grasa (110.1%). Las proporciones más altas de inadecuación (adecuación < 100%) en energía y micronutrimentos se observaron en las localidades rurales, indígenas, región sur y nivel socioeconómico bajo. **Conclusiones**. Esta información es un indicador de la disponibilidad y acceso a los alimentos de diferentes estratos de la población y una herramienta para focalizar a los beneficiarios de programas de asistencia alimentaria.

Palabras clave: dieta; nutrimentos; preescolares; México

(1) Centro de Investigación en Nutrición y Salud, Instituto Nacional de Salud Pública. Cuernavaca, Morelos, México.

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Address reprint requests to: Verónica Mundo Rosas. Instituto Nacional de Salud Pública. Av. Universidad 655, col. Santa María Ahuacatitlán. 62100 Cuernavaca, Morelos, México.
E-mail: vmundo@insp.mx

Mexico, as other countries from Latin America, is undergoing a nutritional and epidemiological transition characterized by a significant increase in mortality rates from chronic, non-transmissible diseases, such as type 2 diabetes, hypertension, and myocardial infarction,[1] and by an increase in prevalence of overweight and obesity.[2,3] Conversely, morbidity and mortality related to acute infectious diseases, such as diarrhea and respiratory infections, have decreased significantly over the last decades.[4,5] In addition, an important decrease in the prevalence of stunting (10.1 percent points between 1988 and 2006)[3] and anemia (4.3 percent points between 1999 and 2006)[6] in preschool children has been documented. However, prevalences are still high; at present, the prevalence of stunting is 9.9% and anemia 16.6%. A significant proportion of children and women of childbearing age are affected by deficiency of micronutrients such as iron and zinc.[7] Apart from increasing morbidity and mortality rates, said deficiency has an adverse effect on children's growth and psychomotor development.[8,9]

Those conditions are the result of sociodemographic and lifestyle changes, in which dietary behaviors could be playing an important role.[10]

In Mexico, the national nutrition surveys conducted in 1988 and 1999 have documented the energy and macronutrient intakes[11,12] in several population groups, making it possible to observe the polarization of food intake and nutrient contribution among population groups from different socioeconomic strata and regions of the country. For example, a low intake of iron, zinc, folic acid, calcium, and vitamins A and C has been observed in preschool children of low socioeconomic status living in the southern region, in contrast with high adequacies of fat and proteins and low intake of fiber in children living in the northern and Mexico City regions.[13]

The objective of this study is to document the current intakes of energy and macro and micronutrients by children less than 5 years old, according to characteristics such as locality, region and socioeconomic status.

Material and Methods

We analyzed information from the Mexican National Health and Nutrition Survey 2006 (ENSANUT 2006) conducted in Mexico, which was a probabilistic, stratified, and clustered sampling study representative at the national, regional and state levels. The design of the survey allowed the collection of data related to the health and nutrition status of the Mexican population.

Population and sample size

The ENSANUT 2006 included a total sample of 48 600 households. A subsample corresponding to a third of the whole sample was selected for dietary information.[14] The proportion of eligible households contributed data on children aged 1-4 years of age was 24%.

On the basis of this criterion, dietary information from 3 552 children aged 1 year to 4 years and 11 months, who represent 7 836 674 children nationwide, is included in this study.

Subjects who agreed to participate in the study gave informed consent. The protocol for the survey was approved by the Ethics, Research, and Biosafety Committees from the National Institute of Public Health (INSP).

Data collection

Data were collected between October 2005 and May 2006. Information on food intake of preschool children was obtained through an adapted version of the semi-quantitative food frequency questionnaire found in the Procedure Handbook for Nutrition Projects, published by the INSP.[15] Food is classified in the questionnaire as follows: dairy products, fruits, vegetables, home-made fast food, meats, sausages and eggs, fish and shellfish, legumes, cereals and tubers, corn products, beverages, snacks, candies and desserts, soups, creams and noodles, tortillas, and several other foods (spices, sugar, fats). In addition, data on consumption of nutrient supplements were collected, the analysis of which will not be presented in this paper.

This questionnaire was already validated previously in other studies.[16] At this time, the portion amounts of consumed food were included to increase its precision. The consumed foods (those that represented 95% of the total consumption) from the data of the 24-hour recall questionnaire were identified from the 1999 National Nutrition Survey (ENN 99),[12] obtaining a final list of 102 foods.

The questionnaire was administered by trained and standardized personnel who entered the information into laptop computers. Personnel used food weighing scales (Ohaus Compact Scales. Pine Brook, NJ. USA. Mod. CS5000), cups and measuring spoons, as well as food tables to better identify portion sizes and quantities of foods included in the questionnaire. Portion weight, according to its size (standard, small, very small, regular, large, and very large) was established for every food included in the questionnaire.

The questionnaire was administered to the mother or to the person in charge of feeding the child in order to obtain information regarding the child's food consumption during the 7 days before the interview.

Variables

Energy and nutrient intake. The estimated quantity of energy, fiber, and macro and micronutrients was calculated using four food composition tables and three datasets[17] compiled by a group of researchers from the INSP. These tables include nutritional value of fortified foods with the highest consumption in Mexico, such as cereals and dairy, besides milk distributed by the nutrition program Liconsa and supplement distributed by the Transfer Conditions Program *Oportunidades*.

As for micronutrients, only those of importance for public health (vitamins A and C, folates, total iron, heme iron, zinc, and calcium) were reported.

Intake adequacy percentages. The adequacy was calculated by presenting actual intakes as a percent of the Estimated Average Requirement for proteins, iron, zinc, vitamin C, retinol equivalents; folates were calculated according to age and sex.[18-21]

For calcium, adequate intake value was used, since the estimated average requirement value has not been calculated due to lack of information for such calculations.[22] For carbohydrates and fat, 50 and 30%, respectively, of the energy derived from those macronutrients were used as adequacy values.

The percentage of energy adequacy was estimated on the basis of the Estimated Energy Requirement (EER).[23] For using the EER estimation equations, a physical activity factor had to be included. Because there are no antecedents of physical activity in the Mexican population of preschool age, the low physical activity factor was assigned according to the results of the Torun *et al.* study (1996).[24]

Inadequacy. A child was classified with energy and macro and micronutrient inadequacy when his/her intake was below 100% of the requirement.

Socioeconomic status. A wellbeing indicator was made using a principal components index[25] that included such variables as housing conditions, flooring and roofing materials, ownership of home appliances and electronics (refrigerator, gas stove, and washing machine, TV set, radio, videoplayer, telephone, and computer), and number of rooms (not including bathrooms, kitchen, and halls). The first component accounted for 46% of the total variance. The resulting standardized factor was divided into tertiles to categorize three socioeconomic status groups: low, middle, and high.

Regions. The country was divided into four geographic regions: north, center, Mexico City, and south.*

Type of locality. Localities were classified according to population number as rural (<2500 inhabitants) or urban (≥ 2 500 inhabitants).

Nutritional status. Data on length/height and weight were transformed to z-scores using the WHO/NCHS/CDC reference pattern.[26] Children were classified as underweight, stunted, and wasted according to their z-score (< -2 standard deviations for weight-for-age, length/height-for-age and weight-for-length/height). Children were classified as overweight when their z-score for weight-for-height was >2 standard deviations.

Indigenous ethnicity. Children who spoke a native language were considered indigenous; those who spoke only Spanish were considered non-indigenous.

Data analysis

Intakes and percentages of energy, carbohydrates, proteins, and fat adequacies reported on the individual level greater than 5 standard deviations from their respective means were excluded from the analysis. Likewise, energy adequacy percentages less than 25% were eliminated, as they were implausible values. Details on data managing and cleaning can be found in another article of this supplement.[27] In total, 407 observations, accounting for 10.3% of the original sample were excluded.

Due to the data elimination during the cleaning process, we calculated new expansion factors.

Because data on intake and energy, macro, and micronutrient adequacy percentages are biased toward high values, they are shown as medians, 25 and 75 percentiles of the distribution.

T tests were done to observe differences between intake and energy and nutrient adequacy percentages. Transformations of the dietary continuous variables were generated to approach a normal distribution for dietary variables. Chi-square tests were also done to observe differences in the proportions of inadequacy, stratifying by variables of interest. Differences among geographic

* North: Baja California, Baja California Sur, Coahuila, Chihuahua, Durango, Nuevo Leon, Sonora, and Tamaulipas states. Center: Aguascalientes, Colima, Guanajuato, Jalisco, State of Mexico (except Mexico City's Metropolitan area), Michoacan, Morelos, Nayarit, Queretaro, San Luis Potosi, Sinaloa, and Zacatecas states. Mexico City: Mexico City and its metropolitan area. South: Campeche, Chiapas, Guerrero, Hidalgo, Oaxaca, Puebla, Quintana Roo, Tabasco, Tlaxcala, Veracruz, and Yucatan states.

regions, type of locality, and socioeconomic status categories were analyzed and p-value was adjusted by multiple comparisons (Bonferroni adjustment).[28]

Processing of all results was performed using the SVY module of the Stata Program version 9.0 in order to adjust for the design effect of the survey.

Results

General characteristics of the study population are presented in Table I. Most preschoolers (40.2%) lived in the south region, 57.5% lived in urban localities, and a small proportion spoke an indigenous language (5.9%). Stunting was observed in 12.6%, and 52.5% was in the lower socioeconomic tertile.

Energy and macronutrient intakes and adequacy percentages

Nationwide, median energy intake was 1 070 kcal and median fiber intake was 8.3 g. Total iron intake was 6.2 mg, of which 1.6% corresponded to heme iron (0.1 mg). The adequacy percentage of almost all macronutrients was above 100%, except folates (95.5%), energy (92.4%) and fat (96.7%) (Table II).

Significant differences ($p< 0.05$) were found between the Mexico City and the south regions; the former had higher intakes and adequacies of energy, macronutrients, vitamin A, and calcium than the latter.

The Mexico City region had the highest intake of heme iron (0.14 mg, 2.2% of total iron intake), whereas the lowest intake corresponded to the southern region (0.09 mg, 1.4% of total iron intake) (when comparing both regions).

However, macro and micronutrient adequacies were above 100% in the four regions, except fat and folate in the center (96.1% and 92.2%, respectively) and south (84.4% and 88.6%, respectively) regions. Adequacies of about 300% for protein and vitamin C were observed in all regions of the country.

According to type of locality, greater intakes of energy, macronutrients, vitamins A and C, folates, heme iron, and calcium were observed in urban than in rural localities ($p< 0.05$). The same was noted for energy and macro and micronutrient adequacy percentages ($p< 0.05$), except iron.

Table I
General characteristics of the study population. Mexico. ENSANUT 2006

Characteristics		*Sample (n)*	*Expansion (thousands)*	*%*
Sex	Men	1 836	3 966.5	51.7
	Women	1 716	3 870.2	48.3
Age (years)	1	751	1 766.7	21.1
	2	916	2 015.8	25.8
	3	902	2 077.3	25.4
	4	983	1 976.8	27.7
Nutritional status	Stunting (< -2 z-score)	409	895.9	12.6
	Underweight (< -2 z-score)	190	419.8	5.9
	Wasting (< -2 Z-score)	50	81.8	1.6
	Overweight (> +2 z-score)	191	362.2	5.9
Indigenous ethnicity	Yes	209	379.9	5.9
	No	3 340	7 448.9	94.1
Region	North	587	1 532.9	16.5
	Center	1 374	2 443.3	38.7
	Mexico City	165	1 238.6	4.7
	South	1 426	2 621.8	40.2
Localities	Urban	2 041	5 700.7	57.5
	Rural	1 511	2 135.9	42.5
Socioeconomic Status (tertile)	Low	1 857	3 309.9	52.5
	Middle	1 148	2 662.9	32.4
	High	535	1 843.2	15.1

Table II

Intakes and energy and nutrient adequacy percentages by geographic region and by type of locality in children aged 1 to 4 years. Mexico. ENSANUT 2006

	National*		Geographic regions								Localities			
			North‡		Center§		Mexico city#		South&		Urban≠		Rural∞	
	Median	C (25 , 75)	Median	C (25 , 75)	Median	C (25 , 75)	Median	C (25 , 75)	Median	C (25 , 75)	Median	C (25 , 75)	Median	C (25 , 75)
Intakes														
Energy (kcal)	1 070.3	(788.1, 1412.6)	1 091.5	(817.6, 1439.9)	1 059.5	(776.6, 1393.1)	1 195.7	(921.1, 1494)	995.3[ø,◊,€]	(700.7, 1309.0)	1 105.7	(835.2, 1456.9)	956.9[Δ]	(686.8, 1252.1)
Fiber (g)	8.3	(5.6, 11.7)	8.2	(5.4, 12.3)	8.9	(6.1, 12.8)	8.5	(5.9, 10.6)	7.9	(5.1, 11.5)	8.3	(5.6, 11.7)	8.3	(5.5, 11.9)
Protein (g)	34.9	(25.5, 46.8)	36.1	(25.7, 47.7)	34.8	(24.4, 46.3)	40.9[◊]	(31.7, 51.5)	32.2[ø,◊, €]	(22.3, 43.3)	36.6	(28.1, 49.1)	30.9[Δ]	(21.6, 40.3)
Carbohydrates (g)	151.1	(109.1, 201.9)	149.0	(107.9, 201.5)	147.7	(106.5, 197.7)	159.1	(124.5, 211.8)	145.4[3]	(101.3, 192.6)	156.1	(113.4, 206.9)	140.4[Δ]	(98.4, 187.5)
Fat (g)	37.8	(26.1, 51.7)	39.7	(28.7, 54.2)	37.4[ø]	(25.3, 50.8)	42.2	(32.2, 56.9)	32.7[ø,◊,€]	(21.7, 46.3)	39.9	(28.6, 54.3)	31.6[Δ]	(21.2, 43.9)
Vitamin A (mcg ER)	310.7	(175.2, 509.2)	285.0	(169.5, 437.4)	279.2	(154.6, 465.3)	492.9[ø,◊]	(294.3, 718.5)	266.0[◊,€]	(147.2, 453.1)	347.1	(206.7, 560.9)	224.2[Δ]	(122.8, 388.3)
Vitamin C (mg)	47.9	(25.4, 80.2)	43.0	(22.7, 71.5)	47.6	(26.1, 84.1)	54.3	(35.4, 93.8)	47.1	(24.4, 77.3)	51.1	(27.9, 83.9)	38.6[Δ]	(20.6, 71.4)
Folate (mcg)	125.1	(82.5, 180.5)	133.9	(90.2, 191.4)	126.4[ø]	(85.7, 181.8)	122.7	(84.2, 161.1)	117.5[ø]	(76.3, 173.4)	128.3	(85.1, 186.9)	113.2[Δ]	(73.6, 169.1)
Total iron (mg)	6.2	(3.9, 9.3)	6.4	(4.3, 9.9)	6.3	(3.9, 9.2)	6.3	(4.5, 8.7)	6.3	(3.9, 9.7)	6.3	(4.1, 9.2)	6.1	(3.8, 9.9)
Heme iron (mg)	0.1	(0.05, 0.2)	0.14	(0.07, 0.28)	0.10[ø]	(0.04, 0.21)	0.14[◊]	(0.08, 0.24)	0.09[ø,€]	(0.04, 0.18)	0.14	(0.07, 0.24)	0.07[Δ]	(0.02, 0.14)
Zinc (mg)	4.9	(3.4, 6.9)	4.9	(3.3, 6.8)	4.9	(3.3, 6.9)	5.3	(3.9, 6.7)	4.9	(3.1, 7.0)	5.1	(3.5, 6.9)	4.5	(2.9, 6.7)
Calcium (mg)	769.8	(445.5, 1050.1)	659.4	(387.3, 1025.2)	744.9	(437.7, 1045.2)	900.9[ø]	(622.2, 1083.2)	687.0[◊,€]	(394.2, 989.9)	809.9	(484.3, 1091.1)	620.4[Δ]	(350.5, 931.9)
Adequacy percentages														
Energy	92.4	(68.1, 122.2)	95.9	(69.0, 126.4)	89.7	(66.7, 119.2)	103.2	(80.1, 127.1)	84.6[ø,◊,€]	(60.7, 112.4)	96.1	(71.2, 125.8)	83.9[Δ]	(61.2, 110.4)
Protein	308.6	(218.7, 409.8)	307.6	(222.0, 415.7)	295.7	(208.5, 400.2)	344.9	(289.5, 441.4)	275.9[ø,◊,€]	(190.6, 380.9)	323.0	(237.6, 424.2)	260.6[Δ]	(179.1, 359.7)
Carbohydrates	103.8	(77.3, 138.9)	103.9	(75.2, 140.8)	101.4	(74.3, 136.3)	109.9	(86.9, 138.4)	98.4[€]	(71.8, 132.7)	105.7	(79.3, 140.4)	95.7[Δ]	(71.3, 133.5)
Fat	96.7	(67.8, 136.0)	105.8	(75.2, 143.0)	96.1[ø]	(65.0, 132.3)	110.1	(84.4, 145.9)	84.4[ø,◊,€]	(56.2, 121.9)	104.9	(72.5, 142.2)	84.1[Δ]	(54.5, 114.3)
Vitamin A	135.5	(78.2, 228.4)	124.1	(77.4, 197.3)	123.5	(69.2, 201.9)	222.6[ø,◊]	(132.9, 317.5)	118.1[◊,€]	(65.2, 201.9)	153.3	(92.7, 247.2)	100.4[Δ]	(55.2, 167.0)
Vitamin C	320.7	(166.9, 543.8)	287.5	(153.5, 490.4)	312.9	(167.1, 561.4)	393.7	(207.8, 617.1)	305.5[◊]	(157.4, 539.4)	338.4	(183.8, 562.5)	249.2[Δ]	(131.6, 482.9)
Folate	95.5	(63.8, 138.1)	102.3	(70.3, 149.8)	96.2[ø]	(66.1, 136.5)	95.4	(65.8, 123.8)	88.6[ø]	(57.3, 134.9)	99.8	(66.5, 140.8)	85.5[Δ]	(55.9, 127.4)
Iron	192.8	(122.6, 286.4)	195.6	(130.9, 303.3)	190.9	(119.8, 275.3)	198.5	(128.7, 264.6)	190.9	(118.8, 294.4)	193.8	(125.2, 288.6)	188.2	(114.6, 286.1)
Zinc	173.9	(119.3, 248.8)	172.3	(118.5, 245.7)	168.9	(116.1, 241.9)	184.5	(137.1, 251.8)	170.5	(107.8, 257.7)	178.2	(126.9, 253.0)	160.2[Δ]	(102.8, 238.6)
Calcium	130.5	(73.9, 192.9)	113.5	(67.7, 188.0)	128.2	(71.8, 189.8)	157.3[ø]	(107.9, 206.8)	117.1[◊,€]	(64.4, 183.9)	141.9	(80.9, 200.9)	110.3[Δ]	(59.3, 173.5)

C: centile

* Sample cases: 3 552, expansion (thousands): 7 836.7 preschoolers
‡ Sample cases: 587, expansion (thousands): 1 532.9 preschoolers
§ Sample cases: 1 374, expansion (thousands): 2 443.3 preschoolers
# Sample cases: 165, expansion (thousands): 1 238.6 preschoolers
& Sample cases: 1 426, expansion (thousands): 2 621.8 preschoolers
≠ Sample cases: 2 041, expansion (thousands): 5 700.7 preschoolers
∞ Sample cases: 1 511, expansion (thousands): 2 135.9 preschoolers
ø Statistically significant differences (Bonferroni test, $p< 0.012$) comparing north vs center, Mexico City, and south regions
◊ Statistically significant differences (Bonferroni test, $p< 0.012$) comparing center vs Mexico City and south regions
€ Statistically significant differences (Bonferroni test, $p< 0.012$) comparing Mexico City vs south regions
Δ Statistically significant differences (Bonferroni test, $p< 0.05$) comparing urban vs rural localities

Energy and micronutrient inadequacies

Table III presents the proportion of children with energy, fat, and micronutrient inadequacies according to several characteristics.

Nationwide, the highest proportions of inadequacy in preschoolers are found in fat (52.3%), vitamin A (33.6%), folate (52.2%) and calcium (36.4%) intakes.

By disaggregating this data by years of age, we noted that children in the groups of 1- and 4-years-old had a greater proportion of inadequacy compared with 2- and 4-years-old children (p< 0.05). Noticeably, the highest proportion of children with iron inadequacy are 1 year-olds (28.4%) compared with other age groups (p< 0.05).

Regarding indigenous ethnicity, indigenous children had a greater proportion of energy and nutrient inadequacy, about 20%, compared with non-indigenous children (p< 0.05).

The comparison by regions showed that most preschool children with energy, fat, vitamin A, and calcium inadequacies lived in the south region (significant differences between regions).

By type of locality, we found that most children with inadequacy lived in rural localities, the differences being

Table III
PROPORTION OF CHILDREN YOUNGER THAN 5 YEARS WITH ENERGY, FAT AND MICRONUTRIENT INADEQUACIES. MEXICO. ENSANUT 2006

Characteristics		*Energy* %	*Fat* %	*Vitamin A* %	*Vitamin C* %	*Folate* %	*Iron* %	*Zinc* %	*Calcium* %
National		56.9	52.3	33.6	12.0	52.2	16..3	17.7	36.4
Sex	Men	56.8	53.2	31.2	10.6	51.6	15.9	15.9	34.3
	Women	57.1	51.3	35.9	13.5	52.8	16.7	19.6	38.6
Age (years)*	1	48.7	42.4	37.6	11.9	58.5	28.4	21.7	32.8
	2	48.8	44.3	30.5	9.7	50.2	15.0	11.4	30.7
	3	66.5	61.7	26.7	7.8	42.7	8.3	10.1	26.5
	4	62.6	59.4	40.3	18.9	58.6	15.1	28.6	55.8
Nutritional status	Stunting (< -2 z-score)	62.5	62.1	44.1	16.0	59.9	17.6	24.0	48.5
	Underweight (< -2 z-score)	69.7	71.3	32.4	9.3	60.1	10.4	21.7	46.0
	Wasting (< -2 z-score)	78.1	64.7	23.9	15.3	77.3	12.3	26.9	37.5
	Overweight (> +2 z-score)	58.8	42.3	30.3	10.9	43.4	17.2	12.9	24.6
Indigenous‡	Yes	73.1	78.6	66.5	27.1	69.9	22.0	38.5	67.6
	No	56.2	50.9	31.9	11.3	51.3	15.9	16.7	34.8
Region§	North	52.0	42.2	37.4	14.1	45.9	13.2	19.5	43.4
	Center	57.2	53.5	33.2	10.8	52.6	16.8	14.4	32.7
	Mexico City	48.7	45.7	13.2	8.6	48.2	15.2	12.9	23.7
	South	63.5	60.0	41.4	13.5	57.4	18.1	21.9	41.8
Localities#	Urban	53.1	47.6	27.5	10.6	50.1	15.6	15.7	33.4
	Rural	67.2	64.7	49.9	15.8	57.9	18.1	23.2	44.4
Socioeconomic status (tertile)&	Low	66.1	62.9	43.8	17.2	56.9	18.5	23.4	45.9
	Middle	51.7	45.4	28.1	8.3	50.1	13.8	14.8	29.8
	High	47.9	42.8	23.0	8.3	46.8	15.9	11.6	28.6

* Statistically significant differences (χ^2 test, p< 0.012) among categories in the proportions of energy, fat, vitamins A and C, folate, iron, zinc, and calcium inadequacies

‡ Statistically significant differences (χ^2 test, p< 0.05) between categories in the proportions of energy, fat, vitamins A and C, folate, zinc, and calcium inadequacies

§ Statistically significant differences (χ^2 test, p< 0.012) among categories in the proportions of energy, vitamin A, and calcium inadequacies

\# Statistically significant differences (χ^2 test, p< 0.025) between categories in the proportions of energy, fat, vitamins A and C, folate, zinc and calcium inadequacies

& Statistically significant differences (χ^2 test, p< 0.016) among categories in the proportions of energy, fat, vitamins A and C, zinc and calcium inadequacies significant for energy, fat, vitamins A and C, folate, and calcium inadequacies.

Significant differences were also noted by socioeconomic status, with energy inadequacy in 66.1% of children in the low and 47.9% of children in the high fertile. Likewise, differences in fat (62.9% lower and 42.8% upper strata), vitamin A (43.8% lower and 23.0% high tertile), and calcium (45.9% low and 28.6% high tertile) inadequacies were observed.

Energy proportion provided by macronutrients

Table IV shows the proportions of contribution of macronutrients to total energy intake. Nationwide, carbohydrates accounted for 56.7%, proteins for 13.1%, and fat for 32.3% of total energy consumed by preschoolers. When analyzing the macronutrient contribution by age in preschool children, we observed that

Table IV

Proportion of total energy accounted by macronutrients in preschoolers' diets. Mexico. ENSANUT 2006

Characteristics		*Carbohydrates*			*Proteins*			*Fat*		
		Median	*25*	*75*	*Median*	*25*	*75*	*Median*	*25*	*75*
National		56.7	51.1	62.8	13.1	11.5	14.7	32.3	27.5	36.4
Sex	Men	56.8	51.0	62.8	13.0	11.5	14.7	32.2	27.5	36.1
	Women	56.5	51.2	62.9	13.2	11.4	14.8	32.3	27.8	36.7
Age (years)	1	55.2	49.4	61.1	13.9	12.2	15.7	32.9	27.7	36.8
	2	56.6[*]	50.6	62.7	13.3[*]	11.5	15.1	32.4[*]	27.8	36.6
	3	57.1[*,‡]	52.3	62.9	12.8[*]	11.3	14.4	31.8[*]	27.5	35.9
	4	57.4[*,‡]	52.2	64.0	12.6[*]	11.1	14.0	31.8[*,‡]	26.7	36.2
Nutritional status	Stunting (< -2 z-score)	59.6	55.0	67.1	12.6	11.1	14.0	30.0	24.4	34.3
	Underweight (< -2 z-score)	57.5	50.9	65.7	12.8	11.1	13.7	31.4	24.8	36.6
	Wasting (< -2 z-score)	56.3	49.5	61.6	14.4	11.2	15.8	33.3	27.3	36.8
	Overweight (> +2 z-score)	54.1	49.0	60.6	13.6[§]	12.4	15.5	34.1[§]	29.7	37.6
Indigenous	Yes	67.1	60.0	72.7	11.9	10.8	12.9	23.7	18.6	29.1
	No	56.3	50.9	62.0	13.2[#]	11.5	14.8	32.4[#]	27.9	36.5
Region	North	54.6	49.6	60.1	12.9	11.1	14.6	34.2	29.7	37.8
	Center	56.8	51.2	63.2	13.1	11.7	14.9	32.3[5]	26.9	36.6
	Mexico City	56.5	50.3	61.1	13.7[≠]	12.2	14.9	32.3	28.8	36.2
	South	58.2[&,∞]	52.6	65.2	12.9[&,≠,∞]	11.3	14.6	31.1[&,≠,∞]	25.3	35.5
Localities	Urban	55.8	50.6	61.4	13.3	11.7	14.8	32.8	28.5	36.7
	Rural	59.4[ø]	53.6	66.3	12.6[ø]	11.1	14.4	30.1[ø]	24.6	34.9
Socioeconomic status (tertile)	Low	58.7	52.9	65.3	12.7	11.2	14.4	30.7	25.2	35.3
	Middle	56.1[◊]	50.1	61.8	13.3[◊]	11.4	14.8	33.1[◊]	28.7	37.0
	High	54.9[◊]	49.9	59.9	13.6[◊]	12.2	15.0	33.2[◊]	29.1	37.2

[*] Statistically significant differences (Bonferroni test, $p< 0.012$) comparing with 1-year-old children
[‡] Statistically significant differences (Bonferroni test, $p< 0.012$) comparing with 2-year-old children
[§] Statistically significant differences (Bonferroni test, $p< 0.012$) comparing with children who were classified as being underweight (< -2 z- score)
[#] Statistically significant differences (Bonferroni test, $p< 0.05$) comparing with children who spoke an indigenous language
[&] Statistically significant differences (Bonferroni test, $p< 0.012$) comparing with children from the north region
[≠] Statistically significant differences (Bonferroni test, $p< 0.012$) comparing with children from the center region
[∞] Statistically significant differences (Bonferroni test, $p< 0.012$) comparing with children from Mexico City region
[ø] Statistically significant differences (Bonferroni test, $p< 0.025$) comparing with children from urban localities
[◊] Statistically significant differences (Bonferroni test, $p< 0.016$) comparing with children of low socioeconomic status
[€] Statistically significant differences (Bonferroni test, $p< 0.016$) comparing with children of middle socioeconomic status

the proportion of energy from carbohydrates slightly increased with age.

Comparisons by nutritional status showed that energy proportion from fat was greater in obese children compared with those with low weight.

Fat contributed 23.7% of total energy intake for indigenous *vs*. 32.4% for non-indigenous children.

Energy proportion from carbohydrates was greater in the south region (compared with the central and Mexico City regions), while energy proportion from fat was greater in the north region.

A greater proportion of energy from carbohydrates was observed in rural compared with urban localities, whereas a greater proportion of energy from fat was found in urban localities.

The proportion of energy from carbohydrates was greater in the lower than in the highest tertiles and the proportion from proteins was greater in the highest than in the lower tertiles.

Discussion

This manuscript describes current energy and macro and micronutrients intakes in preschoolers, as well as the differences between geographic regions and rural and urban localities in Mexico.

The results of this study indicate a greater intake of energy, fat, and other nutrients on the part of preschoolers living in urban localities compared with those living in rural localities. In addition, the greatest energy, protein, vitamins A and C, zinc, and calcium adequacies were observed in the Mexico City region. This information agrees with the analyses performed with data from the ENN 99.[13]

The sprawling urbanization in low-income countries such as Mexico, with a high intake of food with high energy content and a decrease in physical activity, have led to an increase in overweight and obesity.[29] Some studies showed that the intake of processed foods provides about 39% of energy, animal protein, fat, and carbohydrates of Mexican preschoolers' diet.[32] In addition, another study carried out in 2002 by the National Institute of Medical Sciences and Nutrition, including families from Mexico City and its metropolitan area, reported that per capita consumption of soft drinks was 60 ml. The information was collected through 24-hour recalls. Sugar was found to be the second most consumed food by the population in the lowest socioeconomic quartile.[31]

Furthermore, although adequacies in total iron intake are above international recommendations (roughly 190%), the bioavailable iron content in the diet of Mexican preschoolers is low (1.6%) in relation to their physiologic needs (2.7% to 6.1% of total iron consumed). Thus, iron deficiency is still highly prevalent in this population.[32]

The marked inequality observed in the country as to the proportion of the population with energy and nutrient inadequacies according to socioeconomic conditions is worrisome. A fifth of the population living in the southern region, in rural localities, and of low socioeconomic status has vitamin A, folate and calcium inadequacies. This proportion increases when analysis by indigenous ethnicity is made: about one-third of the indigenous population has energy and nutrient inadequacies; the latter may be affecting the nutritional status of those children, as it has been observed that indigenous children living in urban and rural localities have a 3- and 2-fold greater prevalence of low height and low weight, respectively, compared with non-indigenous children.[33]

The coexistence of high energy and nutrient intakes in urban localities and high proportions of populations with micronutrient inadequacy in the lowest socioeconomic status, together with the presence of overweight and obesity in the country, is characteristic of a nutritional polarization. This phenomenon, known as "the double burden of malnutrition", has been observed in countries such as India, the Philippines, and China.[34]

As for the macronutrient contribution to diet, in general the proportions are within those recommended for this group of age;[35] however, children with overweight (> +2 z-score) and those living in urban locations show the highest proportion (34%, close to the upper limit of recommendations) of fat contribution to diet. The low intake of fiber is noticeable in this age group (about 8 g/day), being little more than half of that recommended for children 1 to 3 years old, and less than one-third of that recommended for children 4 years old and over.[36]

Data showed in this study has some limitations: The use of an instrument such as the food frequency questionnaire may cause an overestimation of the reported information about vitamins and minerals. However, it is a validated instrument to report energy and macronutrient intakes.[37,38] Another limitation is that in children it is common to underreport certain kinds of food such as snacks, candies and biscuits.[39] But in this survey we tried to minimize this potential information bias during the interview of the person in charge of caring for the children. An additional limitation is that we did not have enough information about the amount of nutrient supplement (number of pills or spoonfuls), leading to a possible underestimation of the nutrient intake. However, we do not believe that it is a significant problem in the estimation of nutrient intake, since only 11% of the children reported consuming nutrient supplements. Hence, this information was not included in the analysis.

Comparisons with data from the prior national surveys are not possible since information was collected through a different instrument.[40] Despite such limitations, the results allowed us to observe that comparisons by geographic regions and types of localities are consistent with the survey findings.

The high adequacy of protein calls for the necessity of a secondary analysis for differentiating its intake depending on the source (vegetal or animal). That analysis could help as a protein quality indicator, and differences among population strata could be observed as well.

In view of the documented results, it becomes more important to know, in detail, which foods predominate in the preschoolers' diets and to detect those that could be affecting their quality. To date, the level of association between dietary factors and overweight/obesity in Mexican preschool children is not known. Nonetheless, there is available scientific evidence pointing to dietary factors, mainly the consumption of soft drinks, as playing a role in the presence of obesity in children in the United States of America.[41]

The information related to iron intake is noteworthy. When comparing iron intake data from the ENN 99 with the same data from this study we can observe a large difference in the consumption of this nutrient. However, this difference could be accounted for by methodological procedures, as data on food composition, including iron, was more accurate in the 2006 survey.

In conclusion, knowledge about children's food intake and the measurement of levels up to those that meet international recommendations on energy and nutrient intake for children can be valuable tools to formulate or redesign health, education, and nutrition interventions aimed at this age group and to target at-risk population groups.

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References

1. Albala C, Vio F, Yañez M. Epidemiological transition in Latin America: A comparison of four countries. Rev Med Chil 1997;125(6):719-727.
2. Rivera J, Barquera S, Campirano F, Campos I, Safdie M, Tovar V. Epidemiological and nutritional transition in Mexico: Rapid increase of non-communicable chronic diseases and obesity. Public Health Nutr 2002;14:113-122.
3. Rivera-Dommarco J, Cuevas-Nasu L, Shamah-Levy T, Villalpando-Hernández S, Avila-Arcos MA, Jiménez-Aguilar A. Estado nutricio. México: In: Olaiz-Fernández G, Rivera-Dommarco J, Shamah-Levy T, Rojas R, Villalpando-Hernández S, Hernández-Avila M, Sepúlveda-Amor J. Encuesta Nacional de Salud y Nutrición 2006. Cuernavaca, México: Instituto Nacional de Salud Pública, 2006: 85-103.
4. Barquera S, Hotz C, Rivera J, Tolentino L, Espinoza J, Campos I, *et al.* Food consumption, food expenditure, anthropometric status and nutrition-related diseases in Mexico. In: The double burden of malnutrition. Food and Nutrition Paper. Rome: Food and Agriculture Organization of the United Nations, 2006: 1-18.
5. Sepulveda J, Bustreo F, Tapia R, Rivera J, Lozano R, Lozano R, *et al.* Improvement of child survival in Mexico: The diagonal approach. Health System Reform in Mexico. Lancet 2006;368(9551):2017-2027.
6. Villalpando-Hernández S, Mundo-Rosas V, Shamah-Levy T, Rivera-Dommarco J, Mauricio-López ER. Anemia. In: Olaiz-Fernández G, Rivera-Dommarco J, Shamah-Levy T, Rojas R, Villalpando-Hernández S, Hernández-Avila M, *et al.* Encuesta Nacional de Salud y Nutrición 2006. Cuernavaca, México: Instituto Nacional de Salud Pública, 2006: 111-119.
7. Villalpando S, García A, Ramírez I, Mejia F, Matute G, Shamah T, *et al.* Iron, zinc and iodide status in Mexican children under 12 years and women 12-49 years of age. A probabilistic national survey. Salud Publica Mex 2003;45 Suppl 4:S520-S529.
8. Pollit E, Saco-Pollit C, Jahari A, Husaini M, Huang J. Effects of an energy and micronutrient supplement on mental development and behavior under natural conditions in undernourished children in Indonesia. Eur J Clin Nutr 2000;54:80-90.
9. James WP, Nelson M, Ralph A. Socioeconomic determinants of health. The contribution of nutrition to inequalities in health. BMJ 1997;314(7093):1545-1549.
10. Romieu I, Hernandez M, Rivera J, Ruel M, Parra S. Dietary studies in countries experiencing a health transition: Mexico and Central America. Am J Clin Nutr 1997;65 Suppl:1159S-1165S.
11. Flores M, Cortés C, Rivera M, Rivera J, Sepúlveda J. Consumo de energía y nutrimentos en mujeres mexicanas en edad reproductiva. Salud Publica Mex 1998;40:161-171.
12. Rivera J, Shamah T, Villalpando S, González de Cossío, Hernández B, Sepúlveda J. Encuesta Nacional de Nutrición 1999. Estado nutricio de niños y mujeres en México. Cuernavaca, Morelos, Mexico: Instituto Nacional de Salud Pública, 2001.
13. Barquera S, Rivera J, Safdie M, Flores M, Campos I, Campirano F. Energy and nutrient intake in preschool and school age Mexican children: National Nutrition Survey 1999. Salud Publica Mex 2003;45 Suppl 4:S540-S550.
14. Palma O, Shamah-Levy T, Franco A, Olaiz G, Méndez-Ramírez I. Metodología. In: Olaiz-Fernández G, Rivera-Dommarco J, Shamah-Levy T, Rojas R, Villalpando-Hernández S, Hernández-Avila M, *et al.* Encuesta Nacional de Salud y Nutrición 2006. Cuernavaca, México: Instituto Nacional de Salud Pública, 2006: 19-33.
15. Ramírez I, Mundo V, Rodríguez S, Vizuet I, Hernández N, Jiménez A. Encuestas dietéticas. En: Manual de procedimientos para proyectos de nutrición. 2006. [Consulted 2007 November]. Available at: http://www.insp.mx/Portal/insp_publica/proy_nutricion.pdf.
16. Hernández-Avila M, Romieu I, Parra S, Hernández-Avila J, Madrigal H, Willett W. Validity and reproducibility of a food frequency questionnaire to assess dietary intake of women living in Mexico City. Salud Publica Mex 1998;39:133-140.
17. Safdie M, Barquera S, Porcayo M, Rodríguez S, Ramírez C, Rivera J, *et al.* Bases de datos del valor nutritivo de los alimentos. Compilación del Instituto Nacional de Salud Pública. Mexico: Instituto Nacional de Salud Pública, 2004.
18. Institute of Medicine. Protein. In: Dietary Reference Intakes (DRI'S) for Energy, Carbohydrates, Fiber, Fat, Protein and Amino Acids (Macronutrients). Washington, DC: Institute of Medicine, 2005: 589-630.

19. Institute of Medicine. Vitamin C. In: Dietary reference intakes for: Vitamin C, Vitamin E, selenium and carotenoids. Washington, DC: Institute of Medicine, National Academy Press, 2000: 95-185.
20. Institute of Medicine. Dietary reference intakes for: vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium and zinc. Washington, DC: Institute of Medicine, National Academy Press, 2000: 650.
21. Institute of Medicine. Folate: In: Dietary reference intakes for: Thiamin, riboflavin, niacin, vitamin B6, folate, vitamin B12, pantothenic acid, biotin and choline. Washington, DC: Institute of Medicine, National Academy Press, 2000: 196-305.
22. Institute of Medicine. Calcium. In: Dietary reference intakes for: Calcium, phosphorus, magnesium, vitamin D and fluoride. Washington, DC: Institute of Medicine, National Academy Press, 2000: 71-145.
23. Institute of Medicine. Dietary reference intakes for: Energy. Washington, DC: Institute of Medicine, National Academy Press, 2000: 107-264.
24. Torun B, Daviel PSW, Livingstone MBE, Poalisso M, Sackett R, Spurr GB. Energy requirements and dietary energy recommendations for children and adolescents 1 to 18 years old. Eur J Clin Nutr 1996;50:S37-S81.
25. Hair JF, Anderson R, Tatham R, Black W. Multivariate data analysis with readings. 3rd. ed. New York (NY): Macmillan Publishing Company, 1992: 223-253.
26. World Health Organization. Measurement of nutritional impact. Geneva: WHO, 1979.
27. Rodriguez S, Mundo V, Jimenez A, Shamah T. Methodology for the analysis of dietary data from the Mexican National Health and Nutrition Survey 2006. Salud Publica Mex 2009;51 suppl 4:S523-S529.
28. University of New England. One-Way ANOVA Bonferroni adjustment. [Consulted on 2008 April 4]. Available at: http://www.une.edu.au/WebStat/unit_materials/c7_anova/oneway_bonferroni_adjust.htm
29. Popkin BM. The nutrition transition in low-income countries: An emerging crisis. Nutr Rev 1994;52(9): 285-298.
30. González D, González-Cossío T, Barquera S, Rivera J. Alimentos industrializados en la dieta de los preescolares mexicanos. Salud Publica Mex 2007;49:345-356.
31. Ávila-Curiel A, Shamah-Levy T, Chávez-Villasana A, Galindo-Gómez C. Encuesta Urbana de Alimentación y Nutrición en la Zona Metropolitana de la Ciudad de México 2002. México, DF: Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán, Instituto Nacional de Salud Pública, 2003: 81-98.
32. Rodriguez S, Hotz C, Rivera J. Bioavailable dietary iron is associated with hemoglobin concentration in Mexican preschool children. J Nutr 2007;137:2304-2310.
33. Rivera J, Monterrubio E, Gonzalez-Cossio T, Garcia R, Garcia A, Sepulveda J. Nutritional status of indigenous children younger than five years of age in Mexico: Results of a National Probabilistic Survey. Salud Publica Mex 2003;45 Ssuppl 4:S466-S476.
34. Kennedy G, Nantel G, Shetty. Assessment of the double burden of malnutrition in six case study countries. In: The double burden of malnutrition. Food and Nutrition Paper. Rome: Food and Agriculture Organization of the United Nations, 2006: 1-18.
35. Department of Health and Human Services. U.S. Department of Agriculture. Dietary Guidelines for Americans. U.S. Washington, DC: DHHS, USDA. [Consulted 2007 October]. Available at: www.healthierus.gov/dietaryguidelines.
36. Gidding S, Dennison B, Birch L, Daniels S, Gilman M, Lichtenstein A, *et al.* Dietary recommendations for children and adolescents. A guide for practitioners: Consensus Statement from the American Heart Association. AHA Circulation 2005;112; 2061-2075.
37. Andersen LF, Lande B, Trygg K, Hay G. Validation of a semi-quantitative food-frequency questionnaire used among 2-year-old Norwegian children. Public Health Nutr 2004; 7(6): 757-764.
38. Malekshahb AF, Kimiagar M, Saadatian-Elahi M, Pourshams A, Nouraie M, Goglani G, *et al.* Validity and reliability of a new food frequency questionnaire compared to 24 h recalls and biochemical measurements: Pilot phase of Golestan cohort study of esophageal cancer. Eur J Clin Nutr 2006;60(8): 971-977.
39. Bingham SA, Cassidy A, Cole TJ, Welch A, Runswick SA, Black AE, *et al.* Validation of weighed records and other methods of dietary assessment using the 24-h urine nitrogen technique and other biological markets. British Journal of Nutrition 1995; 73: 531-550.
40. Barquera S, Rivera J, Safdie M, Flores M, Campos I, Campirano F. Energy and nutrient intake in preschool and school age Mexican children: National Nutrition Survey 1999. Salud Publica Mex 2003;45 Suppl 4: S540-S550.
41. O'Connor TM, Yang SJ, Nicklas T. Beverage intake among preschool children and its effect on weight status. Pediatrics 2006;118(4):1010-1018.