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Energy and nutrient consumption in adults: Analysis of the Mexican National Health and Nutrition Survey 2006

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Abstract

Objective. To describe energy and nutrient intake in adults. **Material and Methods**. The 2006 Mexican National Health and Nutrition Survey is a nationally representative cross-sectional household survey. A food frequency questionnaire was administered (*n*= 16 494 adults). Mean percent of adequacy (PA) and inadequacy (PA < 50%) of total energy and macro- and micro-nutrient intake was calculated for all subjects and by sociodemographic characteristics. **Results**. Significant differences in PA and inadequate macro- and micro-nutrient intakes were found among sex, region, rural/urban area, and socioeconomic status tertile. PA < 50% was higher than 20% for vitamin A (26.2%), fat (24.8%), fiber (23.6%), folic acid (23.5%), vitamin C (21.3%) and calcium (21%). Obese subjects reported a lower energy intake than normal weight subjects. **Conclusions**. A significant proportion of the population was at risk of excessive carbohydrate and fat intake. Across the country there are significant sociodemographic differences in macro- and micro-nutrient intake and a myriad of micro-nutrient inadequacies continue to persist in Mexico.

Key words: nutritional transition; nutritional epidemiology; obesity; eating; diet surveys; Mexico

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Resumen

Objetivo. Describir la ingesta de energía y nutrientes en adultos. **Material y métodos**. La Encuesta Nacional de Salud y Nutrición 2006 (ENSANUT 2006) es una encuesta representativa de México. Se aplicó un cuestionario de frecuencia de alimentos a 16 494 adultos. Se calculó el porcentaje de adecuación (PA) e inadecuación (PA < 50%) de energía y nutrimentos y se estratificó por variables sociodemográficas. **Resultados**. Se encontraron diferencias importantes en la ingesta de nutrimentos entre las regiones, área, sexo y nivel socioeconómico. La ingesta inadecuada (< 50%) fue mayor a 20% en: vitamina A (26.2%), grasa (24.8%), ácido fólico (23.5%), vitamina C (21.3%) y calcio (21%). Los sujetos obesos reportaron una menor ingesta de energía en todos los grupos de edad. **Conclusiones**. Una importante proporción de la población estuvo en riesgo de tener una ingesta excesiva de hidratos de carbono y grasas. En el país hay diferencias importantes en la ingesta de energía y nutrimentos. Sin embargo, aún persisten deficiencias de nutrimentos en México.

Palabras clave: dieta; transición nutricional; transición epidemiológica; obesidad; cuestionario de frecuencia alimentaria; encuestas; México

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Over the past ten years, Mexico has experienced a rapid nutrition transition. Recent studies confirm this phenomenon and have permitted us to observe how the nutrition transition, accelerated in an unprecedented form, is reflected by increases in the prevalence of obesity, chronic disease, and cardiovascular disease mortality that have concomitantly taken place over this time period.[1,2] Diverse socioeconomic, environmental, cultural and demographic factors have been identified as useful determinants of dietary quality.[3,4] Likely related to the emerging nutrition transition in Mexico, increasing urbanization has raised the demand for and supply of high energy-dense fast food; this may be associated with a concomitant change in dietary intake quality, which may in turn affect a person's nutritional status and/or health.[5,6] At the same time, myriad micronutrient deficiencies continue to be a public health problem in Mexico. Diet studies are useful to understand the characteristics and dynamics of dietary intake and its relationship to both health and disease, which in turn helps to identify vulnerable population groups that may need further support from social programs.[7-11]

Adult energy and nutrient intake in Mexico has been described previously using data from the Mexican Nutrition Survey I (ENN 1988) and II (ENN 1999), but only among women of reproductive age.[12-14] Since resources were limited, this group was selected as a study priority due to the central role that women play in Mexican families with regard to intra-household resource allocation and to the subsequent health of household members.[15-19] Until the Mexican National Health and Nutrition survey 2006 (ENSANUT 2006) was conducted, there was no means by which to describe, at the national level, the energy and nutrient intake of adult males of all ages or females older than 49 years of age. Although the food frequency questionnaire (FFQ) method to assess dietary intake tends to overestimate energy intakes by 10-15% compared to assessments based on 24-h dietary recalls,[20,21] it is currently the primary way to assess usual dietary intake, and thus, the dietary quality of a population.[22,23] In addition, those who are overweight or obese (roughly 70% of the Mexican adult population) have a tendency to under-report their dietary intake compared to those of normal weight.[24] Thus, dietary intake data from the adults included in the ENSANUT 2006 must be interpreted with caution. However, it is still important to characterize and assess the adequacy of the total energy and macro- and micro-nutrient intake of the Mexican population, particularly as it pertains to chosen sub-populations (e.g. region, rural/urban area, socioeconomic status –SES-); this is the primary aim of this study. We believe the results of this study will allow for better targeting of nutritional interventions to specific populations where macro- and micro-nutrient deficiencies and excesses exist. Thus, this study describes the total energy and macro- and micro-nutrient intakes of male and female adults aged 20-59 years old who completed a FFQ as part of the ENSANUT 2006.

Material and Methods

The Mexican National Health and Nutrition Survey (ENSANUT 2006) is a nationally representative, cross-sectional, multi-stage, stratified cluster sampling survey that was conducted between October 2005 and May 2006, with sampling power to disaggregate the study sample into urban (population ≥ 2 500 inhabitants) and rural (population < 2 500 inhabitants) areas. The objective of this survey was to characterize the health and nutritional status, as well as the dietary and nutrient intake patterns of the Mexican population. The ENSANUT 2006 collected information on both men and women from all ages. The ENSANUT 2006 allows for the estimation of health indicators at the state level by urban and rural area. The stratification of sampling units was made considering a maximum of six strata per state. To determine the sample size, the power to detect a minimum precision of 8.1% was considered at the state level. A maximum relative error of 25% was set for the state estimators with a 95% confidence level; the sample size was adjusted for a potential non-response rate of 20% and a design effect of 1.7 based on the 1999 Mexican National Nutrition Survey (ENN 1999) and the 2000 Mexican Health Survey. As a result, a sample size of at least 1 476 households per state was obtained, such that a total of 48 600 households were surveyed throughout all of Mexico's 32 states. Survey questionnaires, anthropometric measurements and blood draws were all administered by trained health personnel. Adults included in the survey were asked to complete a self-reported health questionnaire (n= 45 446), anthropometric measures (height, weight and waist circumference) (n= 33 624), blood samples (n= 9 691) and a FFQ (n= 20 306). A detailed description of the sampling procedures and survey methodology has been published elsewhere.[25,26]

Anthropometry

Anthropometric measurements were obtained from adults 20 years and older using internationally accepted procedures;[27] only those aged 20-59 years old who completed a FFQ were included in subsequent analyses (n= 16 494). Field personnel were trained and standardized using conventional protocols. Weight was measured to the nearest 10 g using an electronic scale (Tanita, Model 1583, Tokyo, Japan), and height (to the nearest millimeter) using a stadiometer with precision of 1mm (Dynatop E1, Mexico City, Mexico). Body mass index –BMI- (kg/m^2) was calculated for all individuals with complete height and weight information (*n*= 15 597) and their nutritional status was determined based on WHO cutoff points: underweight (BMI < 18.5); normal weight (BMI 18.5-24.9), overweight (BMI 25-29.9) and obese (BMI ≥ 30).[28] A binary indicator of obese versus non-obese (18.5 ≤ BMI < 30) was also constructed. Those with a BMI less than 10 or greater than 59 (*n*= 149) and pregnant (*n*= 144) were excluded from all analyses.

Regions included in the ENSANUT 2006

The ENSANUT 2006 is representative of the four regions in Mexico: northern, central, Mexico City and southern. These four regions, having common geographic and socioeconomic characteristics, encompass all of Mexico's 32 states, with region (1) north: Baja California, Southern Baja California, Coahuila, Durango, Nuevo Leon, Sonora, Sinaloa, Tamaulipas and Zacatecas; region (2) central: Aguascalientes, Colima, Guanajuato, Hidalgo, Jalisco, Mexico, Michoacan, Nayarit, Querétaro, San Luis Potosí and Tlaxcala; region (3) Mexico City and; region (4) south: Campeche, Chiapas, Guerrero, Morelos, Oaxaca, Puebla, Quintana Roo, Tabasco, Veracruz and Yucatan. This regionalization scheme has been used in previous epidemiologic analyses to make within-country comparisons.[29,30]

Configuration of a socioeconomic status index

Information collected from the ENSANUT 2006 on household conditions (floor material, roof material, wall material, number of persons residing in the household), basic household infrastructure (e.g. water source and disposal) and total number of domestic appliances in the household (e.g., radio, television and refrigerator) was used to construct a SES index. This was done using principal component analysis (PCA) following a methodology reported in the second National Nutrition Survey (ENN 1999).[13,31,32] Households with incomplete data on any of the aforementioned household characteristics were excluded from the PCA (*n*= 55). Based on these household characteristics, the primary factor extracted from the PCA explained 42% of the variability among households, based on their socioeconomic information. This factor had large loadings for household characteristics such as sewer system and indoor plumbing. Households were naturally divided into tertiles based on the value of this primary component, that served as a proxy to classify households as either low, medium or high socioeconomic status.

ENSANUT 2006 dietary information

To estimate the dietary intake of adults included in the ENSANUT 2006, a previously validated semi-quantitative FFQ was used that included 101 foods, or 14 different food groups.[20] Standardized personnel administered the FFQ to a nationally-representative sub-sample of male and female adults (*n*= 16 494) who were asked about their dietary intake over the previous seven days, including the portion size of the foods most often consumed in Mexico according to the ENN 1999. This sub-sample included one of every three households in the entire ENSANUT 2006 sample and all 16 494 adults who completed the FFQ were included in this analysis. The obtained dietary intake data was converted into average grams (g) or milliliters (ml) of food consumed per person per day. A diverse and extensive food composition database compiled by researchers from the National Institute of Public Health (INSP) was then used to determine the mean energy (kcal) and macro- and micro-nutrient intake per capita per day.[33] Individuals with missing and/or aberrant dietary intake data were excluded from all subsequent analyses with respect to diet (*n*= 543).

Total energy, macro- and micro-nutrient intake statistical analyses

To evaluate macro- and micro-nutrient intake, the Dietary Reference Intakes (DRIs) proposed by the Institute of Medicine of the United States were used as the reference.[34] To describe and evaluate the macro- and micro-nutrient intake of adults included in this study, the percent of adequacy was calculated (PA) for energy and selected macro- and micro-nutrients (fiber, protein, fat, carbohydrates, vitamin A, vitamin C, folate, iron, zinc and calcium). The PA compares the estimated Average Daily Nutrient Intake (ADNI) relative to the DRIs for energy and each analyzed nutrient based on the age and sex of each individual. The ADNI were expressed in g, mg or mcg for macro- and micro-nutrients. The PA for energy was calculated using the Energy Estimated Requirement (EER); to calculate the PA for carbohydrates, 50% of total energy intake was used and for fat, 30% of the total energy intake was used, based on the DRIs.[35-37] In addition, the PAs for protein, iron, zinc, vitamin C, vitamin A (Retinal Equivalents) (RE) and folic acid were determined using the estimated average requirement (EAR); whereas for calcium and fiber adequate intake (AI) was used. Risk of total energy, macro- or micro-nutrient inadequacy intake was defined as having a PA < 50%. Individuals were classified as having a risk of excessive intake of carbohydrates when the proportion of carbohydrates included in their total energy intake was > 65%. Excessive fat intake was defined as having a proportion of total energy intake from fat > 35%.[38] Aberrant data was reviewed case by case and corrected when possible. If the reported value was not biologically plausible and the information to correct the case was not available the individual case was eliminated from subsequent analyses (*n*= 543, 3.29%). To estimate the total energy requirement of cases without weight and/or height information (*n*= 897, 5.4%) the median weight or height for the population of the same age and sex was imputed.[39] Average PA and risk of inadequacy intake (PA < 50%) were calculated by sex, BMI category (obese, non-obese), region, rural/urban area, and SES index tertile. The percent of total energy intake from macro-nutrients and saturated fat, and the subsequent percent of adults at risk of excessive carbohydrate and/or fat intake was calculated according to these same sociodemographic factors as well as by age group; underweight individuals were excluded from these analyses (*n*= 160). Due to the skewed distribution of nutrient intake, average PA and risk of inadequacy intake data were expressed by the median and the 25-75 inter-quartile range (IQR). To evaluate statistically significant differences the ADNIs and PAs were log-transformed and means were compared using unadjusted linear regression models. This procedure was also performed for nutrient densities per 1 000 kcal. Multiple comparisons were adjusted using Bonferroni's method. Differences in populations at risk of inadequacy was evaluated using unadjusted logistic regression models.[40] When models were stratified by BMI category only, those with both a calculated BMI and complete dietary intake data were included in the sample size. The complex survey design was accounted for in all statistical analyses using the SVY module with STATA release 9 (College Station, TX, USA).* Statistical significance was defined as a *p*-value < 0.05.

Ethical Considerations

All participants signed an informed consent form prior to the survey interview. The survey and the written informed consent form were approved by the Ethics Committee of the National Institute of Public Health.

Results

A nationally representative sub-sample of 16 494 male and female adults aged 20 years and older who participated in the ENSANUT 2006 were included in this study. Total of 15 746 adults were analyzed after excluding pregnant or lactating women (*n*= 205) and adults with missing information or aberrant dietary intake values (*n*= 543); this final sample size is representative of a population of 47 946 764 nationwide. Characteristics of the study sample are presented in Table I.

Total energy, macro- and micro-nutrient intake, and PA are presented in Table II. Only those non-pregnant or lactating with a calculated BMI and complete dietary

Table I

Characteristics of the study population. Mexico, ENSANUT 2006

	n	%
Sex		
Men	5 898	40.0
Women	9 848	60.0
	15 746	
Age group		
20 to 29	3 856	26.8
30 to 39	5 323	29.9
40 to 49	4 040	25.2
50 to 59	2 527	18.1
	15 746	
Body Mass Index (kg/m^2)		
Low weight	167	1.1
Normal	4 292	28.0
Overweight	6 016	39.3
Obesity	4 829	31.6
	15 304*	
Region		
North	2 934	19.8
Center	5 951	29.7
Mexico city	673	20.6
South	6 188	29.9
	15 746	
Area		
Rural	6 466	19.4
Urban	9 280	80.6
	15 746	
Socioeconomic status tertile		
Low	7 679	30.6
Medium	5 056	34.5
High	2 956	34.9
	15 691	

Sample size: 15 746, weighted cases: 47 648 569
* includes lactating women (*n*= 61)

* Stata Corporation. Stata 7 reference manual extract: release 7. College Station, TX: Stata Press 2001.

Table II

NUTRIENT INTAKE, ADEQUACY AND PERCENT OF INADEQUACY INTAKE (<50%) AT THE NATIONAL LEVEL, BY REGION AND AREA.* MEXICO, ENSANUT 2006

	National		Region								Area			
			North[§,a]		Center[#,b]		Mexico City[&,c]		South[≠,d]		Rural[€]		Urban[Ø]	
	Median	(p 25 - p 75)	Median	(p 25 - p 75)	Median	(p 25 - p 75)	Median	(p 25 - p 75)	Median	(p 25 - p 75)	Median	(p 25 - p 75)	Median	(p 25 - p 75)
Intake														
Energy (kcal)	1731	(1277-2325)	1743[d]	(1288-2329)	1718[d]	(1279-2341)	1782[d]	(1350-2337)	1699[abc]	(1221-2281)	1644	(1189-2253)	1750[◊]	(1296-2336)
Fiber (g)	20.7	(14.7-28.2)	19.2[b]	(13.8-26.7)	22.0[a]	(15.9-30.0)	19.4[b]	(14.3-26.6)	21.2[bd]	(14.8-28.8)	22.7	(15.7-31.2)	20.3[◊]	(14.5-27.6)
Protein (g)	52.5	(38.4-69.7)	52.7[b]	(39.2-70.3)	53.1[a]	(38.6-70.3)	55.2[d]	(40.3-71.6)	50.5[abc]	(36.6-67.4)	47.8	(34.8-65.5)	53.8[◊]	(39.5-70.5)
Fat (g)	49.9	(33.5-69.3)	53.9[b]	(38.3-74.7)	49.2[a]	(33.0-70.0)	53.1[b]	(37.1-69.3)	44.4[abc]	(29.5-64.1)	40.2	(26.4-59.2)	52.1[◊]	(36.2-71.5)
Cholesterol (mg)	186.1	(103.8-290.4)	215.2[b]	(126.4-323.0)	181.1[a]	(98.3-287.8)	176.7[a]	(106.6-268.7)	174.5[abc]	(91.0-283.8)	141.3	(74.0-242.1)	197.3[◊]	(110.4-299.2)
Saturated fat (g)	14.3	(8.7-21.7)	16.0[b]	(10.5-22.8)	14.9[a]	(9.1-23.0)	14.3[a]	(9.1-21.6)	12.5[abc]	(7.4-19.8)	11.0	(6.5-17.4)	15.2[◊]	(9.4-22.7)
Monounsaturated fat (g)	13.9	(8.7-20.4)	15.9[bcd]	(10.6-22.4)	13.5[acd]	(8.2-20.1)	14.7[abd]	(10.0-21.0)	12.4[abc]	(7.5-18.7)	10.5	(6.5-16.6)	14.7[◊]	(9.5-21.2)
Polyunsaturated fat (g)	8.5	(5.4-13.2)	10.2[bcd]	(6.9-14.8)	8.6[dc]	(5.5-13.0)	8.1[ad]	(5.5-12.1)	7.6[abc]	(4.5-12.5)	6.9	(4.0-11.5)	8.8[◊]	(5.8-13.4)
Carbohydrates (g)	262.0	(193.6-353.1)	247.8[bd]	(181.1-329.7)	262.7[a]	(197.5-360.2)	274.7	(202.1-352.7)	265.8[a]	(194.0-363.5)	266.9	(194.7-375.1)	260.5[◊]	(193.1-350.2)
Vitamin A (ER)	465.5	(266.7-757.8)	394.2[cd]	(243.8-631.0)	455.7	(255.8-771.2)	551.5[ab]	(329.7-883.2)	457.3[abc]	(238.1-767.7)	330.1	(189.2-579.7)	501.4[◊]	(291.5-790.8)
Vitamin C (mg)	80.2	(38.5-148.4)	66.4[bc]	(32.4-118.4)	82.5[acd]	(40.5-163.4)	97.2[abd]	(48.0-179.2)	74.4[bc]	(36.2-140.8)	60.7	(27.8-118.7)	85.0[◊]	(42.3-157.7)
Folate (mcg)	228.3	(164.8-309.7)	237.6[bcd]	(171.9-324.5)	234.5[ad]	(169.2-319.2)	233.4[ad]	(171.1-304.4)	213.9[abc]	(152.6-292.9)	204.0	(141.0-289.5)	234.8[◊]	(170.3-313.9)
Iron (mg)	10.6	(7.8-14.3)	10.5[cd]	(7.8-14.5)	10.6[cd]	(7.8-14.5)	10.5	(7.9-13.4)	10.6[ab]	(7.6-14.4)	10.8	(7.6-15.0)	10.5[◊]	(7.8-14.1)
Iron heme (mg)	0.31	(0.15-0.57)	0.41	(0.21-0.71)	0.31	(0.14-0.58)	0.36	(0.20-0.60)	0.25	(0.11-0.47)	0.17	(0.07-0.35)	0.36	(0.18-0.61)
Iron non-heme (mg)	10.1	(7.5-13.7)	10.0	(7.4-13.9)	10.3	(7.5-13.9)	10.1	(7.5-12.9)	10.1	(7.2-13.9)	10.5	(7.4-14.5)	10.1	(7.5-13.5)
Zinc (mg)	7.3	(5.3-9.7)	7.3[d]	(5.4-10.1)	7.4[d]	(5.4-10.0)	7.5[ab]	(5.3-9.5)	7.0[abc]	(4.9-9.3)	6.7	(4.7-9.2)	7.4[◊]	(5.4-9.8)
Calcium (mg)	804.9	(563.3-1123.4)	736.5[bcd]	(504.0-1021.5)	840.8[ad]	(590.5-1176.2)	844.7[a]	(579.3-1160.5)	795.8[ab]	(559.7-1123.7)	806.3	(549.1-1148.7)	804.1[◊]	(567.3-1118.1)
Adequacy (%)														
Energy	87.2	(63.9-114.5)	84.9	(63.7-112.6)	87.7	(64.6-113.8)	88.3	(66.1-114.1)	87.5	(62.5-117.5)	84.4	(61.2-116.0)	87.8	(64.6-114.1)
Fiber	72.0	(51.0-100.3)	65.8[b]	(45.6-93.4)	77.6[acd]	(55.5-104.3)	66.6[d]	(47.7-92.8)	73.9[bc]	(52.2-103.1)	80.2	(55.6-112.2)	70.4[◊]	(50.1-110.3)
Protein	126.9	(93.4-169.9)	128.1[d]	(95.1-170.2)	128.4[d]	(93.9-171.5)	130.7	(97.1-175.4)	122.5[abc]	(88.6-163.9)	116.5	(84.7-160.4)	129.7[◊]	(95.6-172.0)
Fat	73.2	(50.2-103.8)	78.4[bd]	(56.2-110.6)	73.0[ad]	(49.7-103.5)	74.7[d]	(54.8-103.4)	68.0[abc]	(44.4-100.2)	61.6	(41.4-91.4)	75.5[◊]	(53.2-106.7)
Carbohydrates	104.9	(77.2-139.3)	96.6[bd]	(71.4-129.0)	105.9[ad]	(79.2-138.8)	107.2[d]	(78.6-139.2)	109.8[abc]	(79.3-147.4)	111.3	(80.1-152.1)	103.5[◊]	(76.6-137.2)
Vitamin A	83.9	(48.3-140.1)	72.2[cd]	(44.0-115.9)	83.1[bd]	(46.9-141.8)	100.4[abd]	(59.6-157.0)	83.3[abc]	(43.7-142.1)	61.3	(35.2-108.9)	89.6[◊]	(52.6-146.2)
Vitamin C	122.4	(57.8-229.1)	99.8[bc]	(49.2-180.4)	127.7[acd]	(59.4-251.7)	149.1	(69.6-269.8)	114.1[bc]	(55.4-212.9)	92.6	(43.3-182.3)	129.7[◊]	(62.9-239.0)
Folate	71.2	(51.4-96.6)	74.2[bcd]	(53.7-101.4)	73.2[ad]	(52.8-99.6)	72.9[ad]	(53.3-95.1)	66.6[abc]	(47.4-91.4)	63.6	(43.7-90.1)	73.2[◊]	(53.1-98.0)
Iron	154.7	(108.7-211.6)	154.0[cd]	(108.6-214.8)	155.2[d]	(108.9-216.6)	158.5[a]	(110.6-202.8)	152.2[abc]	(106.9-210.1)	154.9	(104.5-221.6)	154.5[◊]	(109.4-209.3)
Zinc	93.7	(68.1-125.7)	95.8[d]	(69.0-128.8)	97.0[d]	(69.7-127.9)	93.7[d]	(68.5-126.2)	89.1[abc]	(63.8-121.8)	86.6	(61.3-121.0)	95.5[◊]	(69.3-127.0)
Calcium	78.4	(54.1-109.2)	71.1[bcd]	(49.2-99.6)	82.1[ad]	(57.4-114.7)	82.6[a]	(56.7-113.3)	77.9[ab]	(53.2-109.8)	78.5	(53.3-112.5)	78.4[◊]	(54.3-108.0)

Continued…

Table II
(CONTINUED)

		Region				Area	
	National[‡]	North[§,a]	Center[#,b]	Mexico City[&,c]	South[≠,d]	Rural[€]	Urban[Ø]
		%	%	%	%	%	%
Prevalence of inadequacy intake							
Energy	11.5	10.8[d]	11.4	9.8	13.1[a]	14.4	10.8[◊]
Fiber	23.6	29.7[bd]	18.8[acd]	26.4[b]	22.5[ab]	19.4	24.7[◊]
Protein	2.9	2.2[d]	2.6[d]	2.0[d]	4.4[abc]	4.2	2.7[◊]
Fat	24.8	19.5[b]	25.2[ad]	20.4[d]	30.9[abc]	37.2	21.8[◊]
Carbohydrates	6.8	7.7	6.6	6.4	6.9	7.4	6.7
Vitamin A	26.2	30.8[b]	27.2[ac]	15.8[bd]	29.4[c]	39.9	22.9[◊]
Vitamin C	21.3	25.4[bc]	20.4[d]	16.4[d]	22.8[ac]	29.9	19.2[◊]
Folate	23.5	20.9[d]	22.3[d]	20.4[d]	28.6[abc]	32.4	21.3[◊]
Iron	2.3	1.8	2.3	2.4	2.6	3.3	2.1
Zinc	10.3	9.2[d]	8.9[d]	8.8[d]	13.4[abc]	14.3	9.3[◊]
Calcium	21.0	26.3[bcd]	18.1[ad]	18.6[a]	22.0[a]	22.2	20.7

* Data was adjusted for the survey design (see methods)
‡ Sample size: 15 746, weighted cases: 47 648 569
§ Sample size: 2 934, weighted cases: 9 475 380
\# Sample size: 5 951, weighted cases: 14 150 450
& Sample size: 673, weighted cases: 9 848 639
≠ Sample size: 6 188, weighted cases: 14 174 101
€ Sample size: 6 466, weighted cases: 9 228 092
Ø Sample size: 9 280, weighted cases: 38 420 477
◊ Statistically different from rural
a,b,c,d. Diffrent superindices represent statistically significant differences among regions

data were included in these analyses. At the national level, a median total energy intake of 1 731 calories (kcal per capita per day) was estimated, equivalent to a PA of 87.2%. Significant differences in median total energy intake were found between the southern region and the three other regions in Mexico, and between urban and rural areas (Table II). The lowest PAs were observed for vitamin A (61.3%), total fat (61.6%) and folic acid (63.6%) and were among those who live in rural areas ($p < 0.05$) (Table II). The median fiber consumption estimated at the national level was 20.7 g, with significant differences among regions (Table II). The PA for protein for the entire study sample was 126.9% (Table II). Protein was identified as being the nutrient with the highest PA, with carbohydrates having the next highest PA across all four regions and both rural and urban areas (Table II). For the entire study sample, a prevalence of inadequacy intake greater than 20% was observed for vitamin A (26.2%), fiber (23.6%), total fat (24.8%), folic acid (23.5%), vitamin C (21.3%) and calcium (21%) (Table II).

When stratified by sex, a median total energy intake of 1 963 kcal was observed in men and 1 592 in women ($p < 0.05$), however the PA for protein, fat and carbohydrates were all higher among women and also statistically significantly different than those among men (Table III). The PA of iron, calcium and folate was higher in men than women ($p < 0.05$) Total energy intakes for the low, medium and high SES index tertile were 1 653 kcal, 1 707 kcal, and 1 825 kcal, respectively, and all statistically significantly different from each other (Table III). The low SES tertile had significantly lower median intakes and adequacies of all the reported macro- and micro-nutrients compared with the high SES tertile, with the exception of the dietary intake of carbohydrates that was not statistically significantly different between the lowest and highest SES tertile (Table III).

Figure 1 shows the median total energy intake by age group, stratified by BMI categories (normal, overweight and obese). A lower energy intake is observed with each rise in age group. Obese subjects reported a lower total energy intake than the normal weight subjects among all age groups. For example, normal adults 20-25 years old reported 1 898 kcal and 55-59 years olds, 1 624 kcal (a 15% decrease) while obese adults 20-25 years old reported 1 810 kcal and 50-59 years old, 1 480 kcal (a 18.2% decrease) (data not shown). When macro- and micro-nutrient intake and PA are compared across BMI categories, normal subjects show significantly higher intakes and PA of most macro- and micro-nutrients (data not shown). However, when the same macro- and micro-nutrients are expressed as densities (per 1 000 kcal) no statistically significant differences are observed across BMI categories (data not shown).

We also estimated the macro-nutrient contribution to per capita total energy intake and the percent of adults at risk of excessive carbohydrate and/or fat intake by different sociodemographic indicators (age group, sex, region, area, SES tertile). At the national level, on average, adults (excluding those who are underweight) consumed 61.5% of their calories from carbohydrates, 11.9% from proteins and 26.2% from fat (Table IV). Fat intake was < 30% across all of the sociodemographic groups (age group, sex, region, rural/urban area, SES tertiles, BMI category) (Table IV). The highest proportion of fat and saturated fat intakes were observed among all those adults living in the northern region and those from the high SES index tertile (Table IV). Based on the entire study sample, a total of 34.8% of the Mexican population is estimated to be at risk of excessive carbohydrate intake and 12.7% of excessive fat intake. Rural areas appeared to have the highest percentage of the population at risk of excessive carbohydrate intake (54.8%) and the lowest of fat (7.6%) (Table IV). In contrast, the northern region had the highest percentage of the population at risk of excessive fat intake (20.7%) (Table IV).

Discussion

Our article describes for the first time the total energy, macro- and micro-nutrient intake of both male and female adults aged 20-59 years old in Mexico. Based on the FFQ administered to a sub-sample of adults in the ENSANUT 2006, we found a median national total energy intake of 1 731 kcal, with a statistically significantly higher total energy intake among males than females across all age groups, as well as in the northern region and Mexico City, when compared to the southern region. At the national level, adequacies were at an acceptable range for all the analyzed nutrients. However, an important limitation of study results, with respect to micro-nutrient intake, is that it is difficult to measure the usual intake of certain micronutrients, such as iron and zinc.[23,41] The more developed northern region, urban areas and the high SES index tertile all showed the highest median intake of total and saturated fat and the lowest median fiber intake. In contrast, those living in rural areas and in the southern region of Mexico had the lowest median intake of fat and micro-nutrients (vitamin A, vitamin C, folate and calcium) and the highest median fiber intake. Although these findings were similar to those observed in 1999 (second Mexican Nutrition Survey),[12] the results from the two surveys cannot be directly compared since the methods were different (e.g. a 24-hr recall was used to assess dietary intake in the 1999 survey, but for logistical reasons a FFQ was used in ENSANUT 2006 and a different food composition table

Table III

NUTRIENT INTAKE, ADEQUACY AND PERCENT OF INADEQUACY INTAKE (< 50%) BY SEX AND TERTILE OF SOCIOECONOMIC LEVEL.* MEXICO, ENSANUT 2006

	Sex				*Socioeconomic level*					
	Men[‡]		*Women*[§]		*Low*[a#]		*Medium*[b&]		*High*[c≠]	
	Median	*(p 25 - p 75)*	*Median*	*(p 25 - p 75)*	*Median*	*(p 25 - p 75)*	*Median*	*(p 25 - p 75)*	*Median*	*(p 25 - P 75)*
Intake										
Energy (kcal)	1963	(1475-2673)	1592[◊]	(1178-2091)	1653[bc]	(1187-2230)	1707[ac]	(1264-2292)	1825[ab]	(1378-2379)
Fiber (g)	22.8	(16.1-30.5)	19.4[◊]	(13.9-26.8)	21.6[bc]	(15.0-30.3)	20.4[ac]	(14.9-28.2)	20.1[ab]	(14.2-27.1)
Protein (g)	57.4	(42.8-77.7)	49.2[◊]	(35.9-65.1)	47.6[bc]	(35.0-64.7)	51.3[ac]	(38.6-68.0)	57.6[ab]	(42.7-75.5)
Fat (g)	55.0	(38.2-77.4)	46.2[◊]	(30.9-65.1)	41.0[bc]	(27.6-60.6)	49.3[ac]	(34.2-68.6)	57.1[ab]	(40.5-76.2)
Cholesterol (mg)	214.5	(121.0-336.7)	168.1[◊]	(92.2-259.2)	158.8[bc]	(79.7-259.3)	185.5[ac]	(105.2-295.0)	207.1[a]	(122.2-309.7)
Saturated fat (g)	15.7	(9.9-23.7)	13.3[◊]	(8.1-20.3)	11.3[bc]	(6.8-17.7)	14.2[ac]	(8.7-21.0)	17.3[ab]	(11.1-24.9)
Monounsaturated fat (g)	15.7	(10.3-22.9)	12.7[◊]	(7.9-18.8)	10.9[bc]	(6.9-17.3)	13.8[ac]	(8.8-20.0)	16.1[ab]	(11.1-22.7)
Polyunsaturated fat (g)	9.6	(6.2-14.5)	7.8[◊]	(5.1-11.9)	7.4[bc]	(4.4-11.9)	8.6[ac]	(5.6-13.3)	9.1[ab]	(6.4-13.8)
Carbohydrates (g)	294.1	(218.1-390.7)	243.2[◊]	(179.9-324.1)	262.3	(189.6-363.0)	259.1	(192.2-351.9)	264.9	(197.1-349.4)
Vitamin A (ER)	457.1	(265.5-739.3)	469.8	(268.0-763.7)	352.4[bc]	(194.4-595.2)	466.2[ac]	(268.4-750.6)	571.6[ab]	(339.1-874.3)
Vitamin C (mg)	77.1	(36.2-142.6)	82.0[◊]	(40.1-153.6)	58.1[bc]	(27.8-114.1)	82.0[ac]	(41.0-147.2)	99.9[ab]	(48.1-181.7)
Folate (mcg)	250.8	(179.9-334.2)	215.2[◊]	(155.5-292.3)	209.8[bc]	(147.0-294.8)	228.9[ac]	(168.8-314.1)	242.9[ab]	(175.6-315.9)
Iron (mg)	11.5	(8.7-15.6)	9.9[◊]	(7.3-13.3)	10.5[c]	(7.5-14.5)	10.3	(7.7-13.9)	10.9[ab]	(8.2-14.4)
Iron heme (mg)	0.38	(0.19-0.69)	0.29	(0.13-0.50)	0.19	(0.08-0.39)	0.32	(0.17-0.55)	0.43	(0.24-0.70)
Iron non-heme (mg)	11.0	(8.3-14.9)	9.5	(6.9-12.8)	10.1	(7.2-13.9)	9.9	(7.3-13.4)	10.3	(7.8-13.8)
Zinc (mg)	8.0	(5.9-10.9)	6.8[◊]	(4.9-9.0)	6.7[bc]	(4.8-9.1)	7.2[ac]	(5.2-9.5)	7.9[ab]	(5.9-10.3)
Calcium (mg)	856.1	(611.5-1186.1)	774.4[◊]	(530.2-1088.8)	772.8[c]	(526.2-1091.5)	786.2	(563.7-1082.3)	852.2[ab]	(583.8-1184.3)
Adequacy (%)										
Energy	79.3	(60.1-106.4)	91.6[◊]	(68.3-120.7)	83.6[bc]	(61.0-114.5)	85.6[ac]	(63.9-114.5)	91.3[ab]	(66.8-114.7)
Fiber	62.4	(43.6-83.7)	79.8[◊]	(56.6-110.1)	75.5[bc]	(52.3-106.1)	72.0[ac]	(50.7-99.9)	69.0[ab]	(50.3-95.3)
Protein	122.2	(91.1-165.3)	130.5[◊]	(95.1-172.5)	116.4[bc]	(84.7-158.0)	124.8[ac]	(93.6-164.3)	139.4[ab]	(102.9-182.7)
Fat	66.0	(46.3-92.4)	79.0[◊]	(53.3-111.3)	63.3[bc]	(42.6-93.0)	73.4[ac]	(51.8-101.8)	83.2[ab]	(58.5-112.7)
Carbohydrates	93.9	(70.7-125.5)	112.4[◊]	(83.3-150.0)	106.2[c]	(78.1-146.8)	103.4	(76.7-139.3)	104.6[a]	(77.0-135.9)
Vitamin A	73.1	(42.5-118.3)	93.6[◊]	(53.3-152.7)	64.7[bc]	(35.7-111.9)	84.4[ac]	(49.1-139.1)	104.1[ab]	(60.2-159.3)
Vitamin C	102.7	(48.3-190.2)	136.3[◊]	(66.3-253.3)	89.6[bc]	(42.6-173.7)	124.4[ac]	(62.1-225.8)	149.2[ab]	(73.9-276.5)
Folate	78.4	(56.2-104.4)	66.8[◊]	(48.2-91.1)	65.2[bc]	(45.5-91.8)	71.4[ac]	(52.6-98.0)	75.9[ab]	(54.8-98.7)
Iron	191.3	(145.5-259.9)	130.5[◊]	(94.7-177.7)	149.8[c]	(102.3-211.1)	151.9[c]	(106.1-207.6)	160.8[ab]	(116.7-217.5)
Zinc	85.1	(63.2-115.6)	99.9[◊]	(72.2-132.5)	85.4[bc]	(61.7-118.4)	91.7[ac]	(67.5-122.6)	101.3[ab]	(75.1-134.0)
Calcium	83.2	(58.7-115.5)	74.7[◊]	(51.2-106.4)	75.3[c]	(50.8-107.4)	76.6[c]	(54.1-105.7)	82.2[ab]	(56.9-116.1)
	%		%		%		%		%	
Prevalence of adequacy < 50%										
Energy	14.3		9.6[◊]		13.9 bc		11.0 a		9.8 a	
Fiber	32.7		17.5[◊]		22.2		24.2		24.6	
Protein	3.0		3.0		4.5 bc		2.5 a		2.0 a	
Fat	29.9		21.4[◊]		35.1 bc		23.0 ac		17.6 ab	
Carbohydrates	9.3		5.2[◊]		7.4		6.8		6.3	
Vitamin A	31.6		22.6[◊]		37.8 bc		25.5 ac		16.9 ab	
Vitamin C	25.6		18.4[◊]		30.1 bc		19.3 ac		15.7 ab	
Folate	17.8		27.3[◊]		30.7 bc		22.0 ac		18.7 ab	
Iron	0.3		3.7[◊]		3.5[c]		2.3		1.5[a]	
Zinc	12.8		8.6[◊]		14.8[bc]		9.5[ac]		7.0[ab]	
Calcium	17.2		23.5[◊]		23.9[bc]		21.3[ab]		18.3[ab]	

* Data was adjusted for the survey design (see methods)

[‡] Sample size: 5 898, weighted cases: 19 179 137

[§] Sample size: 9 848, weighted cases: 28 469 432

[#] Sample size: 7 679, weighted cases: 14 495 259

[&] Sample size: 5 056, weighted cases: 16 344 255

[≠] Sample size: 2 956, weighted cases: 16 508 680

[◊] Statistically different from men

[a,b,c.] Different superindices represent statistically significant differences among socioeconomic index levels

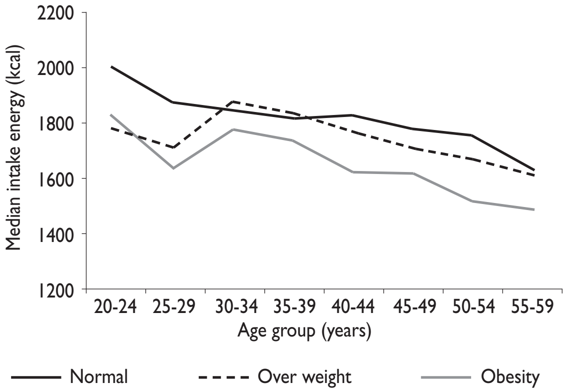

Figure 1. Median energy intake in male and female adults by age group and BMI category

was used); in addition, the target population in the 1999 survey was not representative of all Mexican adults (as mentioned above, only adult women from 12-49 years participated at that time due to budget constraints).

Protein adequacy was higher than 100% among all sociodemographic groups analyzed. While the overweight and obese participants in this study may have under-reported their dietary intake on the FFQ, it is apparent that protein intake is sufficient among the entire Mexican population. This finding may be indicative of the nutrition transition in Mexico where protein intake tends to increase as the economic development of country increases.[7,42,43] Yet, due to the limitations of the FFQ itself, the study's findings that the median total energy intake appears to be adequate and not excessive in Mexico, as well as among all the study's sub-populations, must be interpreted with caution. Moreover, while

Table IV

Proportion of energy from macro-nutrients and percent of adults at risk of excessive intakes. Mexico, ENSANUT 2006

	Percent of energy from macronutrients				*Percent of adults at risk of excessive intakes*	
	Carbohydrates Median (p25, p75)	*Proteins Median (p25, p75)*	*Fat Median (p25, p75)*	*Saturated fat Median (p25, p75)*	*Carbohydrates %*	*Fat %*
Age (years)						
20 to 29	61.4 (55.4-67.8)	11.6 (10.2-13.1)	26.8 (21.6-32.1)	7.7 (5.6-10.1)	35.2	14.8
30 to 39	61.1 (54.9-67.9)	11.8 (10.5-13.5)	26.4 (21.0-31.8)	7.7 (5.4-10.2)	34.4	12.2
40 to 49	61.8 (55.8-68.2)	11.9 (10.7-13.7)	25.7 (20.5-30.7)	7.4 (5.3-9.8)	36.4	11.6
50 to 59	61.6 (55.3-67.0)	12.7 (11.0-14.3)	25.8 (20.9-31.5)	7.6 (5.3-10.0)	32.4	11.7
Sex						
Male	61.5 (55.5-67.9)	11.8 (10.5-13.5)	26.4 (21.0-31.4)	7.6 (5.4-9.9)	34.4	12.8
Female	61.5 (55.2-67.8)	12.0 (10.6-13.7)	26.1 (20.9-31.5)	7.6 (5.4-10.2)	35.1	12.6
Region*						
North	58.5 (52.7-64.2)	12.2 (10.8-14.1)	28.9 (24.1-33.8)	8.5 (6.4-10.9)	22.6	20.7
Center	61.6 (55.3-68.3)	11.9 (10.6-13.6)	26.0 (20.7-31.4)	7.7 (5.5-10.5)	36.0	12.1
Mexico City	61.2 (55.1-66.3)	12.1 (10.5-13.8)	26.5 (22.1-31.3)	7.4 (5.4-9.8)	30.4	11.1
South	63.9 (57.5-70.1)	11.6 (10.4-13.1)	24.2 (18.9-29.9)	6.9 (4.7-9.2)	44.8	8.9
Area						
Rural	66.3 (59.9-72.1)	11.3 (10.3-12.7)	22.1 (17.2-27.8)	6.1 (4.1-8.8)	54.8	7.6
Urban	60.6 (54.5-66.4)	12.1 (10.6-13.8)	27.1 (22.2-32.1)	7.8 (5.8-10.3)	29.9	13.9
Socioeconomic status						
Low	65.4 (58.8-71.2)	11.4 (10.3-12.9)	23.2 (18.0-28.8)	6.4 (4.3-8.9)	51.4	8.7
Medium	61.3 (55.8-67.1)	11.9 (10.5-13.5)	26.4 (21.7-31.1)	7.6 (5.2-9.9)	32.5	11.7
High	58.8 (53.1-64.5)	12.5 (11.0-14.3)	28.3 (23.8-32.8)	8.5 (6.4-11.1)	22.5	16.8
BMI						
Non-obese	61.6 (55.4-68.1)	11.8 (10.5-13.6)	26.1 (20.7-31.4)	7.5 (5.3-9.9)	35.4	13.0
Obese	61.4 (55.4-67.2)	12.0 (10.6-13.6)	26.3 (21.5-31.5)	7.6 (5.5-10.1)	33.8	11.3
Total	61.5 (55.3-67.8)	11.9 (10.6-13.69	26.2 (20.9-31.4)	7.6 (5.4-10.0)	34.8	12.7

* The total sample was 15 746 subjects with an expansion factor of 47 648 569 adults

total energy intake may be adequate across Mexico, this study makes clear that adequate total energy intake is not commensurate with adequate micro-nutrient (and some macro-nutrient) intake for many people. We found a significantly greater percentage of men had inadequate intakes of fiber, vitamin A, vitamin C and fat compared to women; while a greater percentage of women had inadequate intakes of folate and calcium that were significantly different than those of men. Adequate intake of vitamin A for men, and fiber in particular, is associated with chronic disease prevention,[44,45] and among women, both adequate intake of folate and calcium has long been identified as critical to their reproductive and long-term health.[35] This study also identified significant micro- and macro-nutrient inadequacies among both sexes within certain Mexican sub-populations. A greater percentage of the populations in the low SES tertile and rural areas was found to have inadequate intakes of vitamin A, vitamin C, folate, and zinc compared to either higher SES or urban counterparts. Thus, we believe that even greater efforts must be made through federal, state, and community programs to improve the nutrition of those in the low SES and those in rural areas, especially for populations that are both low SES and living in a rural area. However, while this study confirmed that myriad micro-nutrient inadequacies continue to persist among the most vulnerable sub-populations in Mexico, it also alludes to an improvement in iron intake among these populations. This is a positive finding and shows that the many initiatives in Mexico to improve iron intake over the past two decades may be working.[46] In this study, we found that iron adequacies were very high. However, when we stratified by heme- and non-heme iron, only a small percentage of the total iron intake came from animal sources (heme-iron). Thus, our findings could be explained by a greater ingestion of iron-fortified foods, likely as a result of different programs and regulations currently taking place in Mexico in an effort to decrease iron-deficiency anemia. Yet among certain regions and locations, this deficiency continues to be a significant public health problem, as has been demonstrated by previous studies performed at our research center. In addition to the source of iron, other variables such as absorption modifiers (i.e., phytates and tannins) could be contributing to iron-deficiency anemia in certain population groups.[47-49] This phenomenon could explain, in part, why we found that high iron adequacies, along with a high prevalence of anemia, is still a problem.

Another important study finding is that a proportion of the Mexican population appears to be at risk of excessive carbohydrate and fat intake. And furthermore, that a greater percentage of the population in the lowest SES tertile have excessive carbohydrate intake and inadequate fat intake, significantly different than those of the other two SES tertiles; excessive carbohydrate intake and inadequate fat intake was also greater in rural areas and differed significantly from those in urban areas. Taken together, these results indicate that much of the Mexican population may be experiencing a nutrition transition, whereby total energy intake increases as a result of increased carbohydrate and fat consumption, and those in the lowest SES and in rural areas may be most susceptible to the effects of the emerging nutrition transition in Mexico.

When we further compared the macro- and micro-nutrient intake between BMI categories using density per 1 000 kcal, no significant differences were found in this regard, suggesting that people in Mexico, irrespective of their nutritional status, tend to consume diets of similar quality in terms of macro- and micro-nutrient intake; this is consistent with a previous study that found similar prevalences of iron deficiency anemia between obese and non-obese Mexican women.[50]

The high-fat and high-protein Mexican diet has been associated with a rapid increase in non-communicable chronic diseases currently taking place in the country.[51] Our study identifies important differences in both macro- and micro-nutrient consumption across diverse groups, for which micro-nutrient deficiencies must also be carefully acknowledged, along with macro-nutrient excess. Programs that aim to reduce carbohydrate and fat intake while increasing micro-nutrient intake could provide a dual opportunity to prevent nutrition-related chronic diseases associated with both over- and under-nutrition.

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