Intake of trans fats and other fatty acids in Mexican adults: results from the 2012 and 2016 National Health and Nutrition Surveys

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Abstract

Objective. To estimate usual intake and the prevalence of excessive intake (PE) and insufficient intake (PI) of trans fatty acids (FAs) and other dietary FAs in the Mexican adult population in 2012 and 2016, and to compare these time points. **Materials and methods.** Data were collected through dietary recall using the five-step multiple-pass method of the 2012 and 2016 Mexican National Health and Nutrition Surveys. Prevalences were estimated using the Iowa State University method. Linear and logistic regressions were used for analytic comparisons. **Results.** Both in 2012 and 2016, we observed high PE in trans FA, saturated FA, and total fat. High PI was found for polyunsaturated FA, omega 6, omega 3, Eicosapentaenoic Acid (EPA) + Docosahexaenoic Acid (DHA).

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Resumen

Objetivo. Estimar y comparar la ingesta usual y la prevalencia de consumo excesivo (PE) y consumo insuficiente (PI) de ácidos grasos (AG) trans y otros AG en adultos mexicanos en 2012 y 2016. **Material y métodos.** La información dietética se obtuvo utilizando el método de recordatorio de 24 horas de cinco pasos múltiples de las Encuestas Nacionales de Salud y Nutrición 2012 y 2016. Las prevalencias se estimaron utilizando el método de la Universidad Estatal de Iowa y se utilizaron regresiones lineales y logísticas. **Resultados.** En 2012 y 2016 se observó una PE elevada para los AG trans, AG saturados y grasas totales, así como elevadas PI en AG poliinsaturados, omega-3, omega-6, y Ácido Eicosapentaenoico (EPA) + Ácido Docosahexaenoico (DHA).

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In 2016, PE was lower in trans FAs (29.1 vs. 38.4%), total fat (14.9 vs. 17.8%), saturated FAs (45.6 vs. 54.6%). PI was also lower in omega 3 FA (90.7 vs. 92.8%), omega 6 FA (39.8 vs. 62.2%), and EPA + DHA FA (96.3 vs. 99.6%; $p<0.05$) ($p<0.05$) vs 2012. **Conclusion.** Mexican adults showed notably high PE in trans FA, saturated FA, and total fat, as well as high PI in polynsaturated FA, omega 6, omega 3, and EPA. Given the associated health risks, it is critical to implement nutrition policies that regulate trans and saturated FAs in Mexico and faciliate improved dietary quality towards more polyunsaturated and omega 3 FAs, and less trans and saturated FAs.

Keywords: trans fatty acids; inadequate intake; fatty acids; adults

La PE en 2016 fue menor que en 2012 para AG trans (29.1 vs. 38.4%), grasas totales (14.9 vs. 17.8%), AG saturados (45.6 vs. 54.6%), omega-3 (90.7 vs. 92.8%) y omega-6 (39.8 vs 62.2%) ($p<0.05$). Se observó una mayor inadecuación de EPA + DHA FA en 2016 (99.6 vs. 96.3%; $p<0.05$) vs 2012. **Conclusión.** Los adultos mexicanos tuvieron PE elevadas de AG trans, AG saturados y grasas totales, así como elevadas PI de AG poliinsaturados, omega-3, omega-6 y EPA. Considerando las implicaciones en salud, es fundamental implementar políticas alimentarias que regulen los AG trans y saturados en México y mejoren la calidad de la dieta hacia más AG poliinsaturados y omega-3, y menos AG trans y saturados.

Palabras clave: ácidos grasos trans; ingesta inadecuada; ácidos grasos; adultos

Since 1980, Mexico has seen a 48% increase in coronary heart disease (CHD) due to adverse trends in major risk factors and suboptimal use of CHD treatments.[1] In efforts to decrease the prevalence of CHD, dietary recommendations have consistently recommended reducing total fat intake to 30% of dietary energy or less.[2] However, evidence suggests that specific dietary fatty acids (FAs) play a key role in both the cause and prevention of CHD.[3]

Multiple studies show that dietary intake of trans FAs increases low-density lipoprotein (LDL)-cholesterol in plasma, reduces high-density lipoprotein (HDL)-cholesterol, and increases the ratio of total and LDL-cholesterol to HDL-cholesterol, all of which are considered surrogate markers for CHD risk.[4,5] While saturated FA intake has similar effects on surrogate markers, the strongest demonstrated association with CHD has been specifically linked to trans FAs.[3] Furthermore, notable reductions in CHD rates have been shown when saturated FA intake is replaced by a combination of poly- and monounsaturated FA, as well as with sufficient intake of omega 3 and omega 6 FAs.[3]

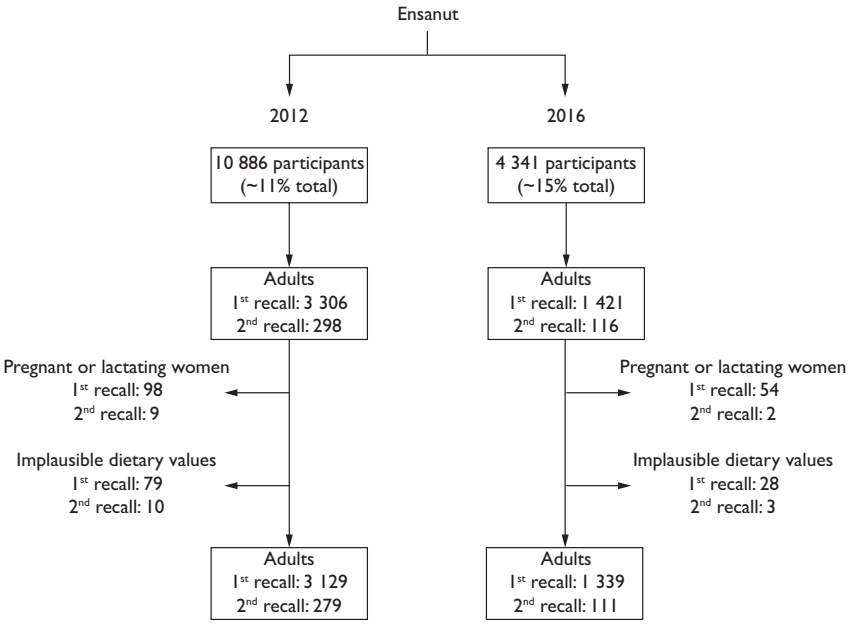
Despite well-established guidelines for total fat and FA consumption, including the joint Food and Agriculture Organization of the United Nations / World Health Organization (FAO / WHO) expert consultation for the prevention of chronic diseases,[6] reliable adequacy and intake data are scarce, both in Mexico and worldwide.[7] Therefore, the aim of this study was to estimate the usual intake and PE and PI of trans FAs and other dietary FAs in the Mexican adult population in 2012 and 2016, and to compare these time points.

Materials and methods

Design and study population

Data were obtained from the National Health and Nutrition Surveys (in Spanish, Ensanut) for the years 2012 and 2016. Each survey used a probabilistic stratified cluster sampling design and was representative of the Mexican population at the national and regional levels, as well as for urban and rural areas. Sampling procedures and methodology for both surveys are described elsewhere.[8,9] To assess dietary intake, a 24-hour dietary recall (24HR) was collected from a random subsample of ~11% (n=10 886) and ~15% (n=4 341) of Ensanut 2012 and 2016 participants, respectively. A second 24HR interview was conducted on a nonconsecutive day after the first interview in a random subsample of ~9% of the 10 886 participants (n=981) for Ensanut 2012 and ~7% of 4 341 participants (n=295) for Ensanut 2016.

The study included adults aged >20 years. We excluded pregnant and lactating women (n=98 in 2012 and n=54 in 2016) and subjects with implausible values reported for dietary energy and main macro- and micronutrients (n=79 in 2012 and n=28 in 2016).[10] The final analytic sample consisted of 3 129 adults from Ensanut 2012 and 1 339 adults from Ensanut 2016 (figure 1). The Research, Ethics, and Biosafety Committees of the National Institute of Public Health of Mexico approved the protocol for both Ensanut surveys. Written informed consent was obtained from all Ensanut study participants.



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Ensanut: *Encuesta Nacional de Salud y Nutrición*

Figure 1. Sample selection of Mexican adults in the Ensanut 2012 and 2016

Dietary intake

Data on dietary intake was collected through automated software using a standardized 24HR adapted for the Mexican population from the five-step multiple-pass method (MP-24H).[11] Detailed information on the MP-24H methodology, processing and analysis is reported elsewhere.[10] Energy and nutrient content values were determined using the Mexican Food Database (in Spanish *Base de Alimentos de México*, BAM).[12,13]

Estimation of usual intake and prevalence of insufficient or excessive intake

We estimated means and standard deviations (SD) of usual intake distributions for total energy, carbohydrate, protein, total fat, trans FAs, and other FAs (polyunsaturated, omega 3, EPA (eicosapentaenoic acid) + DHA (docosahexaenoic acid), omega 6, and saturated FAs) in the total population and by sociodemographic variables. We used the Iowa State University (ISU) method to remove the intra-individual variability[14] through the Software for Intake Distribution Estimation (PC-SIDE) version 1.0.* We also estimated the energy contribution (%E) for total fat, trans FA, and other FAs of interest in relation to total energy intake, as well as the prevalence of excessive intake (PE), prevalence of insufficient intake (PI), and their standard errors. For trans FA, the PE is estimated as the proportion of usual %E of trans FA above the cutoff point of >1%E recommended by FAO/WHO[6] and the threshold of >0.5%E proposed by Qianyi Wang and colleagues,[15] which has been associated with the risk of CHD mortality. For total fat and other FAs, we used as a cutoff point for PE or PI the Acceptable Macronutrient Distribution Range (AMDR), and estimated excessive or insufficient intake as the proportion of usual intake above the upper value of the AMDR (U-AMDR) or below the lower bound of the AMDR (L-AMDR).

Sociodemographic variables

The population was classified by sex (males and females) and age into adults aged 20-64 years and >65 years. Areas with <2 500 inhabitants were classified as rural, while areas with ≥2 500 inhabitants were classified as urban. The country was divided into four geographic regions: Northern, Central, Mexico City, and Southern.[6,7] A socioeconomic index was obtained using principal component factor analysis applied to household characteristics and assets.[16] The index was divided into tertiles: low, medium and high.

* Department of Statistics C for A and RD. Software for Intake Distribution Estimation (PC-SIDE) version 1.02. Iowa State University, 2003.

Statistical analysis

Sociodemographic characteristics (sex, age, area, region, and socioeconomic status tertile [SET]) were used as analytic disaggregates, taking into account survey design effect and sample weights. We used linear regression models considering year of survey as an interaction term, as well as pairwise comparisons of marginal effects with Bonferroni's multiple comparison correction for mean usual intake of total energy, carbohydrate, protein, total fat, trans FA, and other FAs across sociodemographic characteristics. To compare the prevalence of either insufficient or excessive intake, we used the aforementioned procedure adjusting logistic regression models instead of linear regression. All analysis were performed with Stata version 14 (Stata Corp)‡ using complex survey commands (SVY module).

Results

The samples analyzed represented 65 and 61 million Mexican adults in the years 2012 and 2016, respectively. Just over half of the sample population were women, and most were between 20 and 64 years old. Most participants inhabited urban areas (~75%), and around half were from the Mexico City or Central regions (supplementary table I).[17]

At the national level, macronutrient contributions to total energy were similar in 2012 and 2016 but varied by sociodemographic characteristics (figure 2a and 2b). In 2016, total fat contribution to energy was lower at the national level, as well as in older adults, urban residents, people in low and medium SET, and in the Northern, Central, and Mexico City regions as compared to 2012.

Usual intake (UI)

The UI of macronutrients in grams per day (g/d) and %E at the national level and by sociodemographic characteristics are shown in supplementary tables II-IV.[17] UI and %E was higher in 2012 than in 2016 for: trans FAs (0.48 vs 0.41%E), total fat (30.8 vs 30.1%E), and saturated FAs (10.7 vs. 9.7%E) ($p<0.05$). No differences were observed between years for polyunsaturated FAs (6.4 vs. 6.4%E), omega 3 FA (0.3 vs 0.3%E), or omega 6 FA (2.3 vs. 2.9 %E).

‡ StataCorp. Stata Statistical Software: Release 14. College Station, TX. StataCorp LP, 2015.

Prevalence of excessive intake (PE) of fats

National

In 2016, significantly lower PE was observed at the national level for trans FAs using the two cutoffs >1%E and >0.5%E, total fat (U-AMDR>35%E), saturated FAs (U-AMDR>10%E), when compared to 2012 (table I).

Age and sex

For women, PE in 2016 was lower ($p<0.05$) for total fat, trans FAs (cutoff>0.5%E), and saturated FA as compared to 2012. In 2012, women showed higher PE in total fats, trans FA (cutoff >0.5%E), and saturated FA compared to men, but lower for trans FA (cutoff >1%E). In 2016, they also showed higher PE in total fats than men.

Both younger and older adults showed lower PE in 2016 compared to 2012 in trans FAs (cutoff>0.5%E) and saturated FAs. No differences were observed in total fats or trans FAs when using the >1%E cutoff. Also, older adults showed lower PE for total fat, saturated FA and trans FA for both 2012 and 2016 when compared to younger adults.

Socioeconomic status

Across all socioeconomic tertiles, PE of FAs was generally lower in 2016 than in 2012 ($p<0.05$). In 2012, lower PE was observed in the low SET for total fat, trans FAs, and saturated fat. For 2016, the same pattern was identified as in 2012 (table II).

Area

When comparing 2016 to 2012, adults residing in urban areas had lower PE in trans FAs (cutoff>0.5%E) and saturated FAs. Adults in rural areas showed higher PE from polyunsaturated fats. No differences were observed in rural adults for PE in total fat, saturated FAs, and trans FAs (both >1%E and >0.5%E) (table II). Both 2012 and 2016, adults residing in rural areas had significantly lower PE of total fat, saturated FA, and trans FA (cutoff >0.5%E) (table II).

Region

By region, when comparing with 2012, adults in the Northern region showed significantly higher PE for total fat, and polyunsaturated FA (table III) in 2016. However, in 2012 significantly lower PE was observed in trans FA in comparison with 2016 (cutoff>0.5%E). No differences were observed in PE of saturated FAs

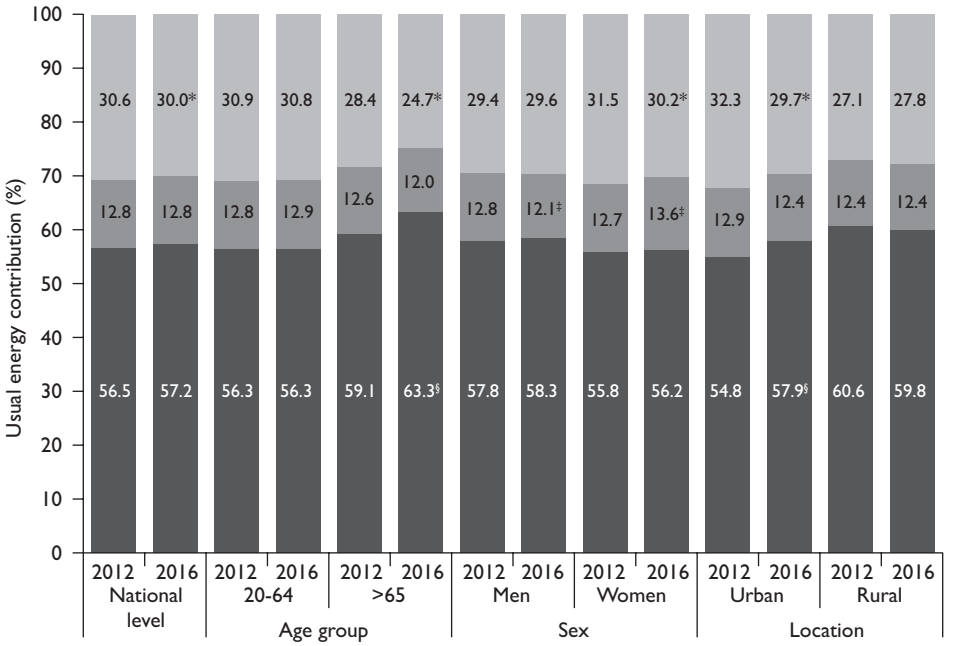
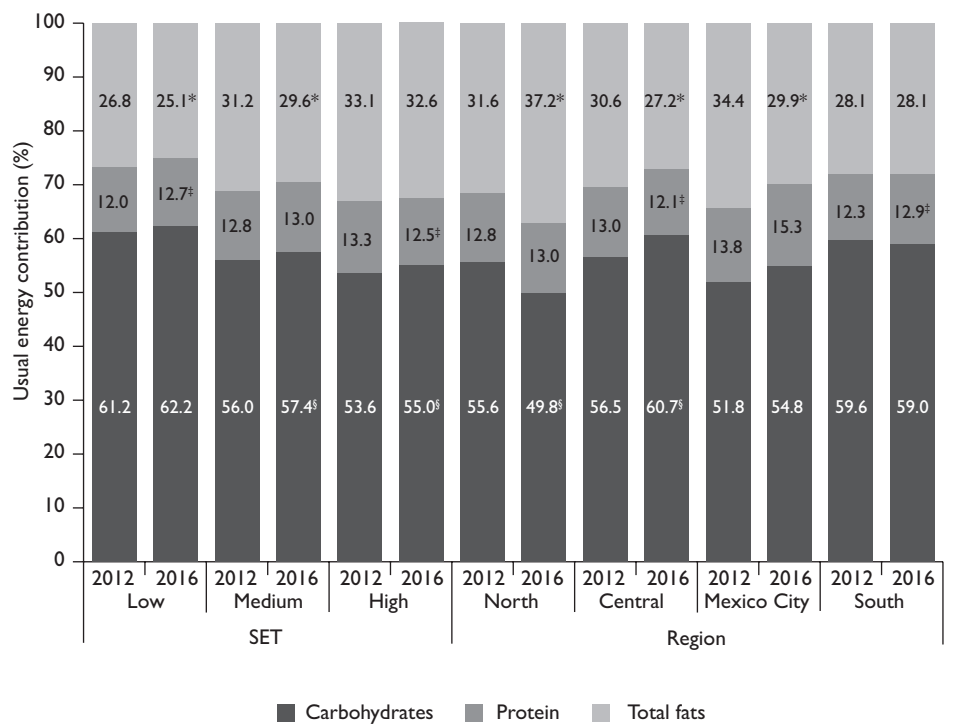


Figure 2a. Macronutrient energy contribution in Mexican adults at the national level and by age group, sex and location. Ensanut 2012 and 2016



* Significant differences in lipid energy contribution between survey years ($p<0.05$).
‡ Significant differences in protein energy contribution between survey years ($p<0.05$).
§ Significant differences in carbohydrate energy contribution between survey years ($p<0.05$).

Figure 2b. Macronutrient energy contribution in Mexican adults by socioeconomic status tertile (SET) and region. Ensanut 2012 and 2016

Table I

Prevalence of inadequate intake of total fat and fatty acids in Mexican adults at national level and by age and sex. Ensanut 2012 and 2016

	2012					2016				
	National	Age group		Sex		National	Age group		Sex	
		20-64 y	≥ 65 y	Male	Female		20-64 y	≥ 65 y	Male	Female
Unweighted, n	3 129	2 370	759	1 355	1 774	1 339	1 117	222	503	836
Weighted (in millions), n	65.0	56.1	8.9	30.7	34.27	61.45	53.15	8.31	29.61	31.84
Energy, kcal/d	1 860 ± 529	1 904 ± 529	1 574.8 ± 38*	2 141 ± 482.2	1 623.4 ± 415*	1 911 ± 545.9	1 972.6 ± 575.5	1 538.1 ± 271.5*	2 130.6 ± 569	1 682.9 ± 383.5*
Inadequate intake prevalence (%)										
Total fat	18.7	20.5	9.4*	13.3	28*	16.2‡	18.3	18.1‡	10.2	24.1*
<20 %E	0.9 ± 0.02	0.7 ± 0.02	2.7 ± 0.11*	2.2 ± 0.08	0.8 ± 0.02*	1.3 ± 0.05	0.6 ± 0.03	15.2 ± 0.4*‡	0.8 ± 0.04	3.0 ± 0.1‡
>35 %E	17.8 ± 0.09	19.8 ± 0.1	6.7 ± 0.18*	11.1 ± 0.17	27.2 ± 0.07*	14.9 ± 0.2‡	17.7 ± 0.2	2.9 ± 0.2*	9.4 ± 0.2	21.1 ± 0.2*‡
Trans FA >1 %E	6.2 ± 0.03	2.8 ± 0.04	0.69 ± 0.04*	3.0 ± 0.04	1.5 ± 0.04*	2.16 ± 0.02‡	2.10 ± 0.02	2.74 ± 0.02	1.80 ± 0.03	1.63 ± 0.02
Trans FA >0.5 %E	38.4 ± 0.02	42.3 ± 0.03	32.6 ± 0.13*	32.0 ± 0.06	52.1 ± 0.02*	29.1 ± 0.04‡	29.6 ± 0.04‡	18.8 ± 0.05*‡	30.1 ± 0.07	26.8 ± 0.05‡
Saturated FA >10 %E	54.6 ± 0.01	61.2 ± 0.05	52.1 ± 0.02*	44.9 ± 0.02	66.4 ± 0.05*	45.6 ± 0.02‡	47.6 ± 0.02‡	31.8 ± 0.08*‡	45.2 ± 0.02	44.9 ± 0.03‡
Polyunsaturated FA	46.9	41.9	63.1*	50.9	48.5	45.7	41.8	72.9*‡	45.9	46.0
<6 %E	45.7 ± 0.02	41.3 ± 0.03	62.0 ± 0.05*	50.1 ± 0.02	45.1 ± 0.02*	44.4 ± 0.03	40.4 ± 0.05	72.3 ± 0.1*‡	45.0 ± 0.05	44.3 ± 0.04
>11 %E	1.2 ± 0.02	0.6 ± 0.02	1.1 ± 0.02	0.8 ± 0.02	3.4 ± 0.03	1.3 ± 0.03	1.4 ± 0.04	0.6 ± 0.03*	0.9 ± 0.04	1.7 ± 0.06
Omega 3 FA	92.8	92.4	89.3*	89.9	90.8	90.7‡	86.1‡	98.3*‡	90.5	85.0*‡
<0.5 %E	92.8 ± 0.07	92.4 ± 0.09	89.2 ± 0.1*	89.9 ± 0.1	90.8 ± 0.08	90.7 ± 0.1‡	86.1 ± 0.2‡	98.3 ± 0.05*‡	90.5 ± 0.2	85.0 ± 0.09*‡
>2 %E	0	0	0.1 ± 0.01	0	0	0	0	0	0	0
Omega 6 FA	62.2	58.8	76.1*	69.6	57.3*	39.8‡	33.7‡	65.0*‡	41.2‡	46.4‡
<2.5 %E	62.2 ± 0.04	58.8 ± 0.04	76.1 ± 0.08*	69.6 ± 0.1	57.3 ± 0.03*	39.8 ± 0.06‡	33.7 ± 0.1‡	65.0 ± 0.16*‡	41.2 ± 0.08‡	46.4 ± 0.03*‡
>9 %E	0	0	0	0	0.04 ± 0.00	0 ± 0.0	0	0	0	0.1 ± 0.01
EPA+DHA FA	96.3	93.0	94.1	86.6	100*	99.6‡	99.1‡	100	99.6‡	99.3
<0.250 g	96.3 ± 0.05	93.0 ± 0.08	94.1 ± 0.1	86.6 ± 0.2	100 ± 0.00*	99.6 ± 0.01‡	99.1 ± 0.03‡	100	99.6 ± 0.02‡	99.3 ± 0.03
>2 g	0	0	0	0	0	0	0	0	0	0

FA: trans fatty acids; E: energy; EPA: eicosapentaenoic acid; DHA: docosahexaenoic acid

* Significant differences between age and sex categories ($p<0.05$).

‡ Significant differences between survey years ($p<0.05$).

Logistic regression models using an interaction term with the year of the surveys and pairwise comparisons of marginal effects with Bonferroni's multiple comparison correction were used for Inadequate intake prevalence.

Linear regression models using an interaction term with the year of the surveys and pairwise comparisons of marginal effects with Bonferroni's multiple comparison correction were used for energy.

Table II

Prevalence of inadequate intake of total fat and fatty acids in Mexican adults by socioeconomic status and area. Ensanut 2012 and 2016

	2012					*2016*				
	Socioeconomic status tertile			*Location*		*Socioeconomic status tertile*			*Location*	
	Low	*Medium*	*High*	*Urban*	*Rural*	*Low*	*Medium*	*High*	*Urban*	*Rural*
Unweighted, n	1 162	1 042	921	1 990	1 139	445	459	435	644	695
Weighted (in millions), n	18.96	19.84	26.19	48.44	16.55	12.13	16.67	32.57	46.74	14.72
Energy, kcal/d	1 903.6 ± 542	1 799.7 ± 553*‡	1878.8 ± 410	1 923.7 ± 558	1730 ± 465*	1 794.1 ± 526.6*	1 983.8 ± 659.3	1 912.8 ± 486.3	1 915 ± 524.1	1 901.3 ± 599
Inadequate intake prevalence (%)										
Total fat	13.7*	42.2*,‡	33.3	35	26.6*	26.2*,§	23.0*,§	33.4	29.8	22.2*
<20 %E	8.1 ± 0.1*	9.4 ± 0.06*	0	1.8 ± 0.02	13.4 ± 0.08*	20.4 ± 0.09*,§	5.8 ± 0.04*,‡,§	0.3 ± 0.05	4.5 ± 0.09§	9.6 ± 0.07*
>35 %E	5.6 ± 0.08*	32.8 ± 0.04‡	33.3 ± 0.1	33.2 ± 0.04	13.2 ± 0.08*	5.8 ± 0.07*	17.2 ± 0.05*,‡,§	33.1 ± 0.3	25.3 ± 0.1§	12.6 ± 0.07*
Trans FA >1 %E	2.2 ± 0.04*	6.5 ± 0.05‡	9.1 ± 0.07	1.1 ± 0.04	0.25 ± 0.01	0.86 ± 0.03*	2.54 ± 0.03§	2.69 ± 0.03§	2.6 ± 0.03§	1.03 ± 0.03
Trans FA >0.5 %E	20.5 ± 0.08*	38.4 ± 0.03*,‡	55.5 ± 0.03	57.7 ± 0.05	17.5 ± 0.15*	14.2 ± 0.12*,§	29.0 ± 0.05‡,§	35.1 ± 0.05§	32.30 ± 0.04§	21.3 ± 0.10*
Saturated FA >10 %E	26.2 ± 0.08*	56.9 ± 0.03*,‡	85.7 ± 0.18	67.0 ± 0.04	32.3 ± 0.06*	21.4 ± 0.07*	54.7 ± 0.03‡	50.8 ± 0.04§	50.3 ± 0.02§	29.9 ± 0.08*
Polyunsaturated FA	61.8*	47.3*,‡	36	42.5	64.2*	61.3*	53.3*,‡	38.7	45.5	58.6*
<6 %E	58.9 ± 0.02*	47.0 ± 0.03*,‡	32.9 ± 0.1	40.5 ± 0.04	61.3 ± 0.02*	60.9 ± 0.08*	51.0 ± 0.03*,‡	36.0 ± 0.1	44.0 ± 0.05	53.0 ± 0.02*,§
>11 %E	2.9 ± 0.02	0.3 ± 0.01*‡	3.1 ± 0.1	2.0 ± 0.04	2.9 ± 0.01	0.4 ± 0.02*,§	2.3 ± 0.03‡,§	2.7 ± 0.1	1.5 ± 0.06	5.6 ± 0.05*,§
Omega 3 FA	92.4*	96.7*,‡	81.8	89.2	98.8*	93.4*	94*,§	84.2	90.3	93.5§
<0.5 %E	92.4 ± 0.04*	96.7 ± 0.08*,‡	81.8 ± 0.2	89.2 ± 0.1	98.8 ± 0.04*	93.4 ± 0.05*	94.0 ± 0.2*,§	84.2 ± 0.3	90.3 ± 0.19	93.5 ± 0.16§
>2 %E	0	0	0	0	0	0 ± 0.00	0	0	0	0
Omega 6 FA	77.8*	69.3*,‡	39.8	52.7	79.0*	69.2*,§	42.3*,‡,§	31.0§	34.7§	60.2*,§
<2.5 %E	77.8 ± 0.05*	69.3 ± 0.09*,‡	39.8 ± 0.07	52.7 ± 0.02	79.0 ± 0.06*	69.2 ± 0.1*,§	42.3 ± 0.08*,‡,§	31.0 ± 0.2§	34.7 ± 0.1§	60.1 ± 0.04*,§
>9 %E	0	0	0.02 ± 0.00	0	0	0	0	0.1 ± 0.01	0	0.1 ± 0.00
EPA+DHA FA	92.5*	97.5*,‡	99.8	99.7	84.4*	98.2§	99.7‡,§	99.1	98.7§	99.5
<0.250 g	92.5 ± 0.1*	97.5 ± 0.07*,‡	99.8 ± 0.02	99.7 ± 0.01	84.4 ± 0.2*	98.2 ± 0.05§	99.7 ± 0.02‡,§	99.1 ± 0.05	98.7 ± 0.06§	99.5 ± 0.02
>2 g	0	0	0	0	0	0	0	0	0	0

FA: trans fatty acids; E: energy; EPA: eicosapentaenoic acid; DHA: docosahexaenoic acid

* Significant differences between high SET with low and medium SET and urban vs rural location ($p<0.05$).

‡ Significant differences between low and medium SET ($p<0.05$).

§ Significant differences between survey years ($p<0.05$).

Logistic regression models using an interaction term with the year of the surveys and pairwise comparisons of marginal effects with Bonferroni's multiple comparison correction were used for Inadequate intake prevalence.

Linear regression models using an interaction term with the year of the surveys and pairwise comparisons of marginal effects with Bonferroni's multiple comparison correction were used for energy.

Table III

Prevalence of inadequate intake of total fat and fatty acids in Mexican adults by region. Ensanut 2012 and 2016

	2012				2016			
	Region				Region			
	North	Central	Mexico city	South	North	Central	Mexico city	South
Unweighted, n	775	1 130	147	1 077	304	400	148	487
Weighted (in millions), n	13.10	19.0	13.17	19.73	12.0	20.68	10.41	18.43
Energy, kcal/d	1 955 ± 508	1 777 ± 530*,‡	1 770 ± 552*,‡	1 925 ± 532	1 977.2 ± 570.1	1 888.1 ± 537	1 847 ± 421.2	1 933.9 ± 590.3
Inadequate intake prevalence (%)								
Total fat	32.3*	31.5*	37.2*	10.7	52.9*,#	26.9*,‡	18.6‡,#	9.6
<20 %E	2.9 ± 0.05	5.2 ± 0.06	0.9 ± 0.05	3.0 ± 0.1	0.8 ± 0.05	12.7 ± 0.1*,‡,#	12.4 ± 0.3*,‡	3.1 ± 0.1
>35 %E	29.4 ± 0.8*	26.3 ± 0.07*	36.3 ± 0.1*	7.7 ± 0.2	52.1 ± 0.05*,#	14.2 ± 0.1*,‡,#	6.2 ± 0.3‡,#	6.5 ± 0.2
Trans FA (>1 %E)	5.3 ± 0.07*	0.45 ± 0.02*,‡	12.7 ± 0.07*,‡,§	0.66 ± 0.04	5.8 ± 0.02*	1.1 ± 0.03	0.04 ± 0.06#	0.13 ± 0.01
Trans FA (>0.5 %E)	47.9 ± 0.03*	38.4 ± 0.08*,‡	58.2 ± 0.05*,§	24.9 ± 0.14	35.7 ± 0.03*,#	28.4 ± 0.09*,#	24.3 ± 0.49#	18.2 ± 0.19
Saturated FA (>10 %E)	60.2 ± 0.05*	54.5 ± 0.02*	79.1 ± 0.13*,‡,§	38.3 ± 0.04	56.8 ± 0.04*	40.8 ± 0.03‡,#	50.6 ± 0.05#	40.4 ± 0.05
Polyunsaturated FA	48.1*	49.8*	36.8*	60.5	22.9*,#	55.4‡	52.5‡	58.9
<6 %E	46.0 ± 0.03*	48.7 ± 0.02*	30.7 ± 0.3*,‡,§	58.2 ± 0.03	13.4 ± 0.3*,#	55.2 ± 0.07‡	52.4 ± 0.08‡,#	58.7 ± 0.06
>11 %E	2.1 ± 0.05	1.1 ± 0.02	6.1 ± 0.3§	2.3 ± 0.03	9.5 ± 0.3*,#	0.2 ± 0.02‡	0.1 ± 0.01	0.2 ± 0.01
Omega 3 FA	93.2	97.1‡	65.4*,‡,§	95.2	68.7*,#	95.8‡	82.3*,§,#	94.6
<0.5 %E	93.2 ± 0.07	97.1 ± 0.08‡	64.6 ± 0.2*,‡,§	95.2 ± 0.1	68.7 ± 0.1*,#	95.8 ± 0.2‡	82.2 ± 0.2*,§,#	94.6 ± 0.1
>2 %E	0	0	0.8 ± 0.07	0	0 ± 0.0	0	0.1 ± 0.01	0
Omega 6 FA	59.3*	68.4*,‡	46.6*,§	74.4	14.5*,#	61.8‡	32.3*,‡,§	60.4#
<2.5 %E	59.3 ± 0.05*	68.2 ± 0.03*,‡	43.7 ± 0.06*,§	74.4 ± 0.09	12.4 ± 0.3*,#	61.6 ± 0.05‡	32.1 ± 0.07*,‡,§	60.4 ± 0.09#
>9 %E	0	0.2 ± 0.00	2.9 ± 0.09§	0	2.1 ± 0.1*	0.2 ± 0.01	0.2 ± 0.01	0
EPA+DHA FA	100*	94.1*,‡	92.2‡	85.1	100	99.0#	98.6	98.1#
<0.250 g	100 ± 0.00*	94.1 ± 0.1*,‡	92.2 ± 0.08*	85.1 ± 0.1	100*	99.0 ± 0.08*,#	98.6 ± 0.09	98.1 ± 0.05#
>2 g	0	0	0.00 ± 0.01	0	0	0	0	0

FA: trans fatty acids; E: energy; EPA: eicosapentaenoic acid; DHA: docosahexaenoic acid

* Significant differences between South with North, Center and Mexico city ($p<0.05$).

‡ Significant differences between North with Mexico city and Center ($p<0.05$).

§ Significant differences between Center and Mexico city ($p<0.05$).

Significant differences between survey years ($p<0.05$).

Logistic regression models using an interaction term with the year of the surveys and pairwise comparisons of marginal effects with Bonferroni's multiple comparison correction were used for Inadequate intake prevalence.

Linear regression models using an interaction term with the year of the surveys and pairwise comparisons of marginal effects with Bonferroni's multiple comparison correction were used for energy.

and trans FAs (cutoff>1%E). In the Central region, PE in trans FAs (cutoff>0.5%E), saturated FA, and total fats were lower in 2016 as compared to 2012. No difference was observed in PE of trans FAs (cutoff>1%E). Adults living in Mexico City in 2016 had a significantly lower PE linked to total fats, saturated FA, and trans FAs (both cutoff>1%E and cutoff >0.5%E) relative to 2012. Finally, in adults in the Southern region no significant PI differences were found in total fats, saturated FAs, and trans FAs (both cutoff>1%E and cutoff>0.5%E).

Prevalence of insufficient intake of fats (PI)

National

A significantly lower PI of omega-3 FA (L-AMDR < 0.5%E) and omega-6 FA (AMDR < 2.5%E) was observed at the national level when comparing 2016 with 2012. Only EPA + DHA FA showed a higher PI in 2016 (L-AMDR<0.250 g) (table I). No difference was observed for total fat (L-AMDR < 20%E).

Age and sex

Women in 2016 had lower PI for omega 3 FA and omega 6 FA than in 2012. In men, a similar pattern was evident for omega 6 FA and EPA + DHA FA. In 2012, women showed higher PI compared to men in EPA + DHA FA, but lower for total fat, polyunsaturated FA, and omega-6 FA. In 2016, men showed higher PI in omega 3 FA while women showed higher PI in omega 6 FA (table I). By age, younger and older adults showed lower PI in 2016 compared to 2012 in omega 6 FA. However, we recorded higher PI in older adults for total fat, polyunsaturated FAs, and omega-3 FA across the same years. Also, a significantly higher PI of EPA + DHA was found for young adults in 2016 compared to 2012.

Socioeconomic status

In 2016 PI for total fat in the low SET was higher, while in medium SET it was lower compared to 2012. Also, PI for EPA + DHA FA was higher in 2016 for both low and medium SET. However, lower PI in 2016 was identified for omega-6 FA across the SET tertiles, as well as for omega-3 in the medium SET. Both in 2012 and 2016, as compared to the high SET, higher PI was observed for polyunsaturated FAs, omega 3 FA, and omega 6 FA in the low SET (table II).

Area

Comparing 2016 to 2012, adults residing in urban areas had lower PI in omega 6 FA and EPA + DHA FA and higher PI of total fats, while adults in rural areas had a significantly lower PI in polyunsaturated FAs, omega-3 FA, and omega-6 FA, but higher PI of EPA + DHA FA. In 2012, adults residing in rural areas had higher PI of total fats, polyunsaturated FA, omega-3 FA, and omega-6 FA, but lower PI of EPA + DHA FA when compared to those residing in urban areas. In 2016, a similar pattern was observed (table II).

Region

Comparing 2016 and 2012 by region, adults in the Northern region showed significantly lower PI of polyunsaturated FA, omega 3 FA, and omega 6 FA in 2016. No differences were observed in PI of total fats or EPA + DHA FA. In the Central region, PI of total fat and EPA + DHA were higher in 2016 than 2012. No differences were observed in PI of polyunsaturated FAs, omega 3 FA, or omega 6 FA. Adults living in Mexico City in 2016 had a significantly higher PI linked to polyunsaturated FA and omega-3 FA compared to 2012. No significant differences were observed for total fats, omega 6 FA or EPA + DHA FA. For adults in the Southern region in 2016, we identified a significantly lower PI in omega 6 FA, but higher PI of EPA + DHA FA in comparison with 2012. No significant PI differences were found in total fats, polyunsaturated FAs, or omega 3 FA.

Discussion

Our findings show that in general, Mexican adults show notably high prevalences of insufficient and excessive intake of FAs. These appear mainly driven by excessive intake of trans FAs (above cutoff) and saturated FAs (above U-AMDR), but insufficient intake (below L-AMDR) of polyunsaturated FAs, omega 3 FA, omega 6 FA, and EPA + DHA FA. In 2016, some improvements were evident from 2012. PE in 2016 was lower for trans FAs, total fats, and saturated FAs, while PI was lower for omega 3 FA and omega 6 FA. However, both PE and PI remained high across both years, particularly for PI of EPA + DHA FA at the national level, for which insufficient intake was higher in 2016 than in 2012. Altogether, these results are of concern to public health since previous evidence suggests that both insufficient and excessive intake in FAs constitute

an important risk factor for CHD, the latter of which has been increasing in Mexico.[1,3]

Although most strata of sociodemographic characteristics showed improvements in PE in trans FAs in 2016 as compared to 2012, overall, PE using the >0.5%E cutoff is notably high across all categories. It is critical to note that when using the FAO/WHO 2008 cutoff, the same PE results are classified as low (tables I-III). Nevertheless, we consider that the 0.5%E cutoff as proposed by Wang Q and colleagues[15] in 2015 is preferable since it was derived using updated information on 1) the lowest point estimate of association with CHD from meta-analyses; 2) lowest trans FA consumption levels as observed globally; and 3) national and international guidelines.

Unlike at the national level, a modest improvement in PI was registered in urban areas for EPA + DHA FA over time. Conversely, PI in EPA + DHA FA in 2016 was higher in young adults, males, those of low and medium SET, and in the Central and Southern regions as compared to 2012. PI of total fat in 2016 was also higher in adults aged ≥65 years, those of low SET, in urban areas, and in the Central region. PE for total fat was similarly higher in the Northern region. PI of polyunsaturated FAs was higher in 2016 in adults aged ≥65 years and in Mexico City.

In general, information on PE and PI in total fat and FAs both globally and in Mexico is scarce. One 2006 study in Mexico by Ramirez Silva and colleagues[18] found that PE in trans FA was 3.6% in adults and 2.7% those aged >60 years. For saturated FA these authors reported PE of 42.8% in adults and 45.2% in those aged >60 years: similar to what we estimated in 2012. Another study using Ensanut 2012 data reported a different PE in saturated FAs when stratified by sex (65% in men and 59% in women) as compared to our calculations (44.9% in men and 66.4% in women).[19] However, comparisons should be interpreted with caution, since there were differences in the design, instruments, and cutoffs used by source surveys.[19,20] Additionally, total fat and FA data were updated in BAM prior to this study, meaning different food composition databases were used.

This study has some limitations. First, intra-individual variability was adjusted in 2016 with information from 8% of the participants. However, the FA-specific intra-individual variability coefficients were highly comparable with 2012 for most sociodemographic characteristics (data not shown). In cases where the 2012 and 2016 intra-individual variability coefficients were unreliable (>0.80), we used the 2012 coefficients (26.5%). Second, we did not consider dietary supplements, which may result in underestimation of usual intake, particularly of omega 3 and omega 6 FA.[19,20] Finally, information on trans FA content of Mexican foods is scarce, which was particularly problematic for branded products since in 2012 and 2016 it was not mandatory to report trans FA content on nutrition labels. As part of this work the information available was updated where possible, however, usual intake and PE in trans FAs may be underestimated.

It should be noted that the food composition tables used to estimate trans FAs intake, as well as the norms around nutritional content declaration on packaged products in Mexico and worldwide have historically depended on food labels which report in grams. The use of this unit limits the precision of the information reported, and can result in rounding to zero for some nutrients present in amounts that would be detectable in milligrams. Many other countries (including Mexico prior to 2021) do not require trans FAs to be declared on nutrition labels and still allow companies to round trans FAs to one decimal in grams, allowing a range of error that facilitates imprecision. To our knowledge, Mexico was the first country to require trans FA content to be reported in milligrams[21] with the update of NOM-051 in 2020, applied from 2021. Therefore, data used in this study does not reflect these improvements in nutrition labelling to verify whether and to what extent PE of trans FA has been underestimated due to imprecision.

Strengths of this study include that it is one of few known studies that describes intake of total fat and FAs in the Mexican population using FAO/WHO intake thresholds.[6] Data used were obtained from national surveys with a probabilistic design and state level representation, by urban and rural national strata.[8,9] Additionally, our study employed the MP-24H,[22] which is considered a gold standard in dietary studies using self-report measures as it limits recall bias, and our usual intake estimates accounted for intra-individual variability.

In conclusion, our results show that Mexican adults show notably high prevalences of insufficient and excessive intake of trans fats and other fatty acids. Nutrition-related policies should aim to improve dietary patterns by increasing intake of polyunsaturated FAs, omega 3 FA, omega 6 FA, and EPA + DHA FA without supplements,[23] and decrease intake of trans FAs and saturated FAs.

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Authors contribution

Ivonne Ramírez-Silva, Azucena Salazar-Piña, Noemí Landa-Gómez and Sofía Barragán-Vázquez contributed to the conception of the study. Analysis and interpretation of data were conducted by Noemi Landa-Gómez, Sofía Barragán-Vázquez, Gabriela Olvera-Mayorga, Ignacio Gómez-Humarán and Ivonne Ramírez-Silva. Noemí Landa-Gómez, Sofía Barragán-Vázquez, Gabriela Olvera-Mayorga, and Azucena Salazar-Piña drafted the first versions of this work. Ivonne Ramírez-Silva, Fabio Da Silva Gómez, Alicia Carriquiry, and Sofía Barragán-Vázquez reviewed and contributed to the final version of the work. All authors read and approved the final manuscript.

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