Dairy consumption patterns in Mexican adults: analysis of three nationally representative surveys, 2012-2018

Leticia Lizbeth Armenta-González, MSc,[1,*] Jesús Gibran Hernández-Pérez, MSc,[2,3,*] Sonia Rodríguez-Ramírez, PhD,[1] Emma L Feeney, PhD,[4] Ruth Argelia Vázquez-Salas, PhD,[2] Luisa Torres-Sánchez, PhD.[2]

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Abstract

Objective. To identify dairy consumption patterns, trends, and associated characteristics in Mexican adults from 2012-2018. **Materials and methods.** We used data from 25 218 adults aged ≥20 years participating in the Mexican National Health and Nutrition Survey (Ensanut, by its acronym in Spanish) 2012, 2016 and 2018. Through a semiquantitative food frequency questionnaire, we estimated the energy-adjusted intake of 23 dairy products. Dairy patterns were identified using the principal component analysis. To identify associated characteristics and trends, we used independent linear regression models for each pattern. We included survey year as an independent variable in trend estimation (stratified by sex and region). **Results.** We identified three dairy patterns: 1) skim milk/light yogurt, 2) fresh cheese/high-fat milk and yogurt, and 3) mature cheese/cream. The highest consumption of all dairy patterns was associated with high education and/or socioeconomic level. Consumption of the "skim milk/light yogurt" and "mature cheeses/cream" patterns increased, whereas "fresh cheese/

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Resumen

Objetivo. Identificar patrones de consumo de lácteos, tendencias y características asociadas en adultos mexicanos entre 2012-2018. **Material y métodos.** Se analizó la información de 25 218 participantes (≥20 años) en la Ensanut 2012, 2016 y 2018. Mediante un cuestionario semicuantitativo de frecuencia de consumo de alimentos se estimó el consumo diario ajustado por energía de 23 lácteos. Los patrones de consumo se identificaron usando un análisis de componentes principales. Las características asociadas y las tendencias se identificaron usando modelos independientes de regresión lineal para cada patrón. El año de la encuesta se incluyó como variable independiente en la estimación de la tendencia (estratificados por sexo y región). **Resultados.** Se identificaron tres patrones: 1) leche light/yogur light, 2) queso fresco/lácteos altos en grasa, y 3) queso maduro/crema. Un mayor consumo de estos patrones estuvo asociado con mayor escolaridad y/o nivel socioeconómico. El consumo de los patrones "leche light/yogur light" y "quesos maduros" incrementó, mientras que el consumo de "queso fresco/leche

* Both authors contributed equally.
(1) Centro de Investigación en Nutrición y Salud, Instituto Nacional de Salud Pública. Cuernavaca, Morelos, México.
(2) Centro de Investigación en Salud Poblacional, Instituto Nacional de Salud Pública. Cuernavaca, Morelos, México.
(3) Escuela de Salud Pública de México. Cuernavaca, Morelos, México.
(4) UCD Institute of Food and Health, Science Centre South, University College Dublin. Dublín, Irlanda.

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Corresponding author: Luisa Torres-Sánchez. Centro de Investigación en Salud Poblacional, Instituto Nacional de Salud Pública. Av. Universidad 655, col. Santa María Ahuacatitlán. 62100 Cuernavaca, Morelos, México.
email: ltorress@insp.mx

high-fat milk and yogurt pattern" decreased steadily. These changes were similar among women and men and in all regions. **Conclusion.** Our findings support the existence of different population-specific dairy consumption patterns with variations over time, mainly determined by socioeconomic characteristics. This approach must be considered to evaluate the association between dairy consumption and health outcomes.

Keywords: dairy products; national surveys; Mexico

y yogur altos en grasa" disminuyó en todas las regiones y similar en hombres y mujeres. **Conclusión.** Los patrones de consumo de lácteos son poblacionalmente específicos socioeconómicamente determinados y con cambios temporales. Este abordaje debe ser considerado al evaluar la asociación entre el consumo de lácteos y resultados en salud.

Palabras clave: productos lácteos; encuestas nacionales; México

Dairy products are considered an essential part of the diet of more than six million people worldwide.[1] From 1981 to 2007, per capita milk consumption increased by 31%, especially in developing countries, where it nearly doubled (from 35 to 68 kg).[2] The main changes over time have been observed in men and low socioeconomic groups.[3] Dairy consumption declines throughout life and is higher among residents of urban than rural areas.[3]

Nutritionally, these products are a good source of calcium, protein, fat, vitamins (A, B2, B6, and B12), iodine, phosphorus, magnesium, and zinc.[4] Consumption of total dairy, mainly milk and cheese, is consistently associated with a lower risk of colorectal cancer, and cardiovascular disease, and probably a lower risk of breast cancer, metabolic syndrome, and type 2 diabetes mellitus (T2D). However, a higher risk of prostate cancer and Parkinson's disease has been reported.[5] The traditional and diverse ways of dairy consumption assessment (total dairy, individual dairy, or dairy classified according to fat content), as well as the prevalence of consumption in different geographical regions, could explain the inconsistencies observed for certain health outcomes.[6,7] The nutritional contribution of dairy products and their role in the genesis of some diseases may be determined by their dietary matrix,[8,9] as well as the existence of possible patterns of dairy consumption based on personal and socio-cultural preferences.

The matrix effect of foods is determined by the structure, composition, and interaction of nutrients. These characteristics influence the bioavailability and absorption of nutrients.[10] A dairy matrix is unique and complex,[8] and can vary according to the structure of each dairy product, i.e., liquid forms like milk, semi-solid compositions such as cheese, and gelatinous matrices like yogurt.[9] Adults aged ≥50 years, who ate dairy fat in an original matrix of cheese during six weeks, showed a significant reduction in total and low-density lipoprotein (LDL) cholesterol. The reduction was less marked in the group that received dairy fat contained in a partial cheese matrix, and no difference was observed in the group that received only butter.[10] Concerning dairy consumption patterns, this approach was used in three studies, identifying at least three patterns.[11-13] One pattern characterized by the consumption of whole milk was associated with higher serum TNF-α as well as lower triglycerides and total cholesterol concentrations in an Irish cross-sectional study.[11] Meanwhile, a similar pattern was significantly associated with lower T2D risk and higher prostate cancer odds, in a Canadian population-based cohort[12] and a case-control study in Mexico City,[13] respectively. Information on dairy pattern determinants is scarce; however, whole milk pattern was mainly reported by Irish men.[11]

With some differences by region, in Mexico, a high proportion of people (ranging from 70.3% in 2012 to 51.3% in 2018) incorporate dairy products into their daily dietary intake,[14,15] particularly whole milk (47.3%) and cheeses (39.6%).[14] However, there is no information about national dairy consumption patterns, and their consumption trend changes over time. The identification of dairy consumption patterns may be useful for improving the evaluation of dairy intake association with some chronic health outcomes, highly frequent in our population. Therefore, we aimed to identify dairy consumption patterns among Mexican adults aged ≥20 years, along with associated characteristics and trend changes from 2012-2018.

Materials and methods

Study design and population

The National Health and Nutrition Survey (Ensanut, by its acronym in Spanish) is a probabilistic household survey with national, regional, urban, and rural representativeness. The participants' selection process in each survey was similar and has been reported previously.[16-18] Briefly, the sampling frame of the 2012 and 2016 surveys was built from the Basic Geostatistical Areas of the 2005 population count, as well as the list of new localities reported in the 2010 Census.[16-18] For Ensanut 2018, the

National Institute of Geography and Statistics of Mexico (Inegi, by its acronym in Spanish) created Primary Sampling Units based on the 2010 Census.[18] To carry out these three surveys, an average of 110 656 Mexican households were visited. In each household, an adult aged ≥20 years was selected whenever possible. The adult participation rate was 78.3% in 2012,[16] 72.0% in 2016,[17] and 97.0% in 2018.[18] All surveys were conducted according to the Declaration of Helsinki guidelines and were approved by the Ethics Committee of the National Institute of Public Health of Mexico (INSP, by its acronym in Spanish). Participants were informed about the details of the study, and all of them gave their written informed consent before the interview. For this analysis, we considered adults ≥20 years old with dietary information, excluding pregnant and lactating women.

Dietary assessment

In all surveys, dietary information for the seven days before the interview was obtained using a semiquantitative food frequency questionnaire of 140 foods, previously validated in adults for estimating energy and nutrient intake.[19] The dairy products included were: whole milk (whole, raw, whole milk powder, evaporated whole milk, and lactose-free whole milk), skim milk (skim, skim milk powder, evaporated skim milk, semi-skimmed milk, and lactose-free skim milk), fresh cheese (panela, fresh, or cottage), mature cheese (chihuahua, manchego type, and gouda), yogurt (plain whole milk yogurt, fruit-flavored yogurt, and low-fat plain yogurt) and cream. The food frequency consumption (ranging from "never" to "six times or more per day"), the number of servings per day, and the serving size of each dairy product were used to estimate its consumption in grams per day (g/d). The total daily dairy consumption was calculated as the sum in grams per day of all products. The energy intake of the diet was estimated from the reported consumption (net grams) and the energy content of each food reported in the food composition database compiled by the INSP.[20] The upper and lower limits of energy intake were estimated following the approach used in Mexican national surveys.[21] The upper limit was calculated from the ratio between reported energy intake and energy requirement according to sex and body mass index (BMI). Subjects with three standard deviations above the mean (n= 241) were excluded. The lower limit was estimated from the ratio between energy intake and basal metabolic rate, which was determined for male and female subjects using the Mifflin-St Jeor equations. Subjects with a ratio <0.05 were excluded (n= 1 112).

Identification of dairy consumption patterns

With the combined information from the three surveys, we used the residual method proposed by Willet[22] to estimate the energy-adjusted intake of each dairy product and conducted a principal component analysis (PCA) to identify dairy consumption patterns. The number of patterns was determined based on the scree plot test with an eigenvalue cutoff of ≥1.0. Dairy products with factorial loading values under -0.30 or over 0.30 were used to characterize each pattern.

Anthropometric

BMI (kg/m^2) was calculated with the information of weight in kilograms and height in meters squared measured at the time of the interview. Three categories were considered according to the cutoff values proposed by the World Health Organization (WHO): 1) underweight or normal weight ≤24.9 kg/m^2; 2) overweight 25-29.9 kg/m^2; and 3) obese ≥30 kg/m^2.

Sociodemographic

Age at the time of the interview was categorized into decades. Educational level was classified as none, elementary or less, middle school, high school, and college or beyond. The family's socioeconomic level (low, medium, and high) was calculated using a PCA method[23] that considered the housing construction materials, the number of household appliances, and electrical devices. Based on the state of residence and the categories used in Ensanut 2016, we formed four regions: 1) North (Baja California, Baja California Sur, Coahuila, Chihuahua, Durango, Nuevo León, San Luis Potosí, Sinaloa, Sonora, Tamaulipas, and Zacatecas); 2) Center (Aguascalientes, Colima, Guanajuato, Hidalgo, Jalisco, State of Mexico, Michoacán, Nayarit, Querétaro, and Morelos); 3) Mexico City and surrounding municipalities from the State of Mexico; 4) South (Campeche, Chiapas, Guerrero, Oaxaca, Puebla, Tlaxcala, Quintana Roo, Tabasco, Veracruz, and Yucatán).[17]

Personal pathological history

Previous diagnosis (Yes/No) of T2D (Has any doctor ever told you that you have diabetes or high blood sugar?) and cardiovascular disease (Has any doctor ever told you that you have or had a heart attack, angina pectoris, or heart failure?) was obtained by self-report. Additionally, in the three surveys, blood pressure

measurement was performed following the technique and procedures recommended by the American Heart Association (AHA). In Ensanut 2012, a mercury sphygmomanometer was used and validated with the Omron HEM-907 XL digital sphygmomanometer, which was used in 2016 and 2018.[24] A history of hypertension (Yes/No) was constructed with the self-report of previous diagnosis or based on mean blood pressure measurements (systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg) during the interview.

The final sample for this analysis was 25 218 adults who participated in Ensanut 2012, 2016, and 2018. Total exclusion was 9.2% (supplementary figure 1).[25]

Statistical analysis

To evaluate a potential selection bias, we compared selected characteristics between all, eligible and analytical samples. Using a complex sample design and the SVY module, we estimated the weighted prevalences and 95% confidence intervals (95%CI) of the selected characteristics. Differences according to the survey year were evaluated using the Chi-square test.

To evaluate the associated characteristics with the dairy patterns score, we used an adjusted independent linear regression model for each covariate. The selection of potential confounders was based on the theoretical relationship. Age and sex models were adjusted by survey year and mutually adjusted between them. Education and socioeconomic models were adjusted by survey year, age, sex, and region, with mutual adjustments between education and socioeconomic level. The region model was adjusted by survey year, age, sex, and socioeconomic level. The T2D model was adjusted by survey year, age, sex, education level, socioeconomic level, region, and BMI. Cardiovascular and hypertension models were adjusted by survey year, age, sex, education level, sociodemographic level, T2D, and region. The reference categories were as follows: age (20-30 years), sex (male), education level (none), family socioeconomic status (low), residence area (rural), region (north), BMI (normal), and absence of chronic diseases (TD2, hypertension, or cardiovascular diseases), respectively. For all the previous models, we applied a Bonferroni test to adjust for multiple comparisons, considering a p-value <0.05 as significant.

To estimate the changes over time in dairy consumption pattern scores we used an independent linear regression model, that included the pattern score as the dependent variable and the survey year as the independent variable. This model was adjusted by all other predictors. Additionally, a stratified analysis by sex and region was conducted. The adjusted mean score of each dairy pattern consumption and its 95%CI were estimated using the "margins" command. In this final model, the Bonferroni correction was applied to compare whether the adjusted mean score differed significantly across survey years: 2018 vs. 2012, 2016 vs. 2012, and 2018 vs. 2016.

The goodness of fit for the models was determined using the assumptions of normality and linearity, as well as the coefficient of determination adjusted for the design (R^2). We conducted the statistical analysis in Stata 16.0;* the figures were created using R version 4.4.2.

Results

We did not observe differences between all, eligible, and analytical samples (supplementary table I).[25] Regarding the analytic sample (table I), most participants were adults aged 20 to 60 years, with the lowest proportion of adults ≥71 years old (5.6%) in the 2016 survey. Compared with Ensanut 2016, 2018 participants had a higher education level (36.1% high school or more), were residents of urban areas (82.3%), and the prevalence of T2D (12.1%) was higher. Meanwhile, the prevalence of hypertension (32.2%) and overweight/obesity (75.5%) were higher than in 2012.

Regardless of the survey year, whole milk was the predominant dairy product consumed (~60%); only ~9% of the participants reported consuming skim milk. Concerning cheese, the highest consumption was attributed to fresh cheese (~50%) in all surveys. However, the consumption of mature cheese doubled in 2018 (31.1%). Approximately a third of the participants reported consuming yogurt, mainly whole milk yogurt (supplementary table II).[25]

Three different dairy consumption patterns were identified and named according to the factor loadings presented in table II: 1) skim milk/light yogurt; 2) fresh cheese/high-fat milk and yogurt; and 3) mature cheese/cream. Compared to the youngest, participants aged 41 to 50 years had higher consumption of the "skim milk/light yogurt" pattern (adjusted mean score= 0.0692, p-value <0.01). "Mature cheese/cream" pattern consumption decreased as age increased (p-value for trend <0.001). Compared to men, women reported higher consumption of "fresh cheese/high-fat milk and yogurt" (adjusted mean score= 0.2641 vs. 0.0198, p-value <0.01), and "mature cheese/cream" (adjusted mean score= 0.0381 vs. -0.0114, p-value= 0.01). All dairy consumption patterns increased with the rise in education level (p for trend <0.001). The "fresh cheese/high-fat milk and yogurt" and "Mature cheese/cream"

* Stata Corp. Stata Statistical Software: Release 16. College Station, TX: StataCorp LP, 2017.

Table I

General characteristics of the study population. Mexican adults aged ≥20 years. Mexico, Ensanut 2012, 2016 and 2018

Characteristics	*Ensanut 2012*			*Ensanut 2016*			*Ensanut 2018*			*p-value*
	n= 2 354	*Prevalence**	*(95%CI)*	*n= 7 545*	*Prevalence**	*(95%CI)*	*n= 15 319*	*Prevalence**	*(95%CI)*	
Expansion (thousands)		53 891			56 086			75 448		
Age (years)										
20-30	529	26.1	23.4,29.1	1 476	28.3	26.3,30.3	3 109	22.7	21.2,24.3	
31-40	575	21.9	19.5,24.4	1 703	21.4	19.7,23.3	3 239	18.6	17.4,19.9	
41-50	483	19.6	17.2,22.3	1 505	19.2	17.6,21.0	3 214	21.1	19.8,22.6	<0.01
51-60	347	14.0	12.2,16.1	1 220	14.4	13.1,15.7	2 413	16.1	15.0,17.3	
61-70	220	9.4	7.6,11.5	952	11.1	9.6,12.7	1 828	12.2	10.3,14.4	
≥71	200	9.0	7.1,11.3	689	5.6	4.9,6.5	1 516	9.2	7.8,10.8	
Sex										
Male	899	44.1	40.9,47.3	2 647	46.9	45.0,48.9	6 800	43.4	42.0,44.8	0.08
Female	1 455	55.9	52.7,59.1	4 898	53.1	51.1,55.0	8 519	56.6	55.2,58.0	
Education level										
None	220	8.7	7.0,10.7	860	7.1	6.2,8.2	1 106	6.0	5.3,6.8	
Elementary school or less	978	38.4	35.6,41.3	2 835	30.3	28.1,32.5	4 758	27.8	26.1,29.5	
Middle school	657	27.8	24.7,31.1	2 326	30.5	28.7,32.4	4 781	30.1	28.7,31.5	<0.01
High school	273	12.7	10.8,14.8	944	17.3	15.7,19.0	2 442	18.9	17.7,20.2	
College or beyond	226	12.4	10.5,14.7	580	14.8	12.9,17.0	2 232	17.2	16.0,18.5	
Family socioeconomic level										
Low	822	26.6	24.1,29.4	2 588	22.5	20.1,25.1	5 882	29.0	27.3,30.9	
Middle	796	32.1	29.3,35.1	2 531	30.7	28.7,32.9	5 101	32.9	31.6,34.3	<0.01
High	736	41.2	37.9,44.6	2 426	46.8	43.6,49.9	4 336	38.0	36.0,40.1	
Residence area										
Rural	805	24.8	22.2,27.5	3 799	25.5	22.4,28.9	3 808	17.7	15.7,19.8	<0.01
Urban	1 549	75.2	72.5,77.8	3 746	74.5	71.1,77.6	11 511	82.3	80.2,84.3	
Region‡										
North	749	25.6	23.4,28.1	2 393	26.2	22.6,30.0	4 984	26.1	24.0,28.3	
Center	702	26.5	23.7,29.4	1 967	30.6	26.0,35.7	4 706	28.6	26.3,31.0	0.60
Mexico City	117	16.7	13.3,20.7	840	15.4	12.5,18.9	503	17.3	14.1,20.9	
South	786	31.2	28.4,34.2	2 345	27.8	24.7,31.1	5 126	28.0	25.8,30.4	
Personal history of										
Diabetes										
No	2 120	88.9	86.5,90.8	6 709	90.6	89.5,91.6	13 519	87.9	86.8,88.9	0.04
Yes	234	11.1	9.2,13.5	836	9.4	8.4,10.5	1 800	12.1	11.1,13.2	
Hypertension										
No	1 620	68.7	65.6,71.6	5 512	74.6	72.7,76.4	10 323	67.8	66.0,69.5	<0.01
Yes	734	31.3	28.4,34.4	2 033	25.4	23.6,27.3	4 996	32.2	30.5,34.0	

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(continuation)

Cardiovascular diseases[§]										
No	2 262	94.6	92.5,96.2	7 333	97.2	96.5,97.7	14 770	96.6	96.0,97.0	<0.01
Yes	92	5.4	3.8,7.5	212	2.8	2.3,3.5	549	3.4	3.0,4.0	
Body mass index (kg/m^2)[#]										
Normal weight	643	29.8	26.7,33.1	1 973	27.6	25.9,29.4	3 693	24.5	23.3,25.8	
Overweight	897	37.1	34.1,40.1	2 931	38.9	36.9,40.8	6 071	39.6	38.3,41.0	0.01
Obesity	814	33.1	30.3,36.1	2 641	33.5	31.4,35.6	5 555	35.9	34.6,37.2	

* Weighted prevalence and 95% confidence interval (95%CI)
‡ North: Baja California, Baja California Sur, Coahuila, Chihuahua, Durango, Nuevo León, San Luis Potosí, Sinaloa, Sonora, Tamaulipas, and Zacatecas; Center: Aguascalientes, Colima, Guanajuato, Hidalgo, Jalisco, State of Mexico, Michoacán, Nayarit, Querétaro, and Morelos; Mexico City and surrounding municipalities from State of Mexico; South: Campeche, Chiapas, Guerrero, Oaxaca, Puebla, Tlaxcala, Quintana Roo, Tabasco, Veracruz and Yucatán
§ Cardiovascular diseases: heart attack, angina pectoris or heart failure
# Normal weight ≤24.9 kg/m^2, overweight 25-29.9 kg/m^2, obesity ≥30 kg/m^2
Ensanut: *Encuesta Nacional de Salud y Nutrición*

Table II
DAIRY CONSUMPTION PATTERNS ACCORDING TO THE FACTOR LOADING MATRIX. MEXICO, ENSANUT 2012, 2016 AND 2018

Type of dairy	*Factor loading*		
	Dairy consumption patterns		
	Skim milk/light yogurt	*Fresh cheeses/ high-fat milk and yogurt*	*Mature cheeses/ cream*
Milk			
Whole*	-0.627	0.360	
Skim‡	0.699		
Cheeses			
Fresh§		0.519	-0.404
Mature#			0.809
Yogurt			
Whole&		0.584	
Light≠	0.323		
Cream		0.452	0.367

Values from 0.30 through -0.30 were excluded for simplicity
* Whole milk: whole, raw, whole milk powder, evaporated whole milk, and lactose-free whole milk
‡ Skim milk: skim, skim milk powder, evaporated skim milk, semi-skimmed milk, and lactose-free skim milk
§ Fresh cheeses: panela, fresh, or cottage
# Mature cheeses: chihuahua, manchego type, gouda, etc.
& Whole yogurt: plain whole milk yogurt, plain yogurt drink, fruit-flavored yogurt, and fruit yogurt drink
≠ Light yogurt: low-fat plain yogurt and low-fat yogurt drink
Ensanut: *Encuesta Nacional de Salud y Nutrición*

intake were mainly reported among participants with a high family socioeconomic level and residents in urban areas. History of T2D and residence in Mexico City were associated with higher consumption of "fresh cheese/high-fat milk and yogurt" (table III).

The adjusted changes over time in the average consumption of the identified patterns are for the entire population and stratified by sex (figure 1) and region of residence (figure 2, supplementary table III).[25] Compared with 2012 the average consumption of the "skim milk/light yogurt" pattern (-0.073 vs. 0.043) in the entire population increased in 2016 with no significant change in 2018 (figure 1A). This trend was similar in males and females (figure 1B-C) and in all regions of the country (figure 2 A-D). The "mature cheeses/cream" pattern consumption showed the highest increase, and this occurred between 2016 and 2018 (figure 1A), mainly among women (figure 1B-C) and in all regions (figure 2 A-D). In contrast, the consumption of "fresh cheese/high-fat milk and yogurt" presented a sustained reduction throughout the period. This trend remained after stratifying by sex, although consumption of the "fresh cheese/high-fat milk and yogurt" pattern was always higher among women (figures 1B, C). The decrease in the consumption of "fresh cheese/high-fat milk and yogurt" pattern was similar in all regions (figure 2 A-D).

Discussion

The analysis of the Ensanut from 2012 to 2018 demonstrates that among Mexican adults there were at least three identifiable dairy consumption patterns: 1) skim milk/light yogurt; 2) fresh cheese/high-fat milk and yogurt; and 3) mature cheese/cream. The average consumption of these patterns varied throughout the study period; the

Table III

CHARACTERISTICS ASSOCIATED WITH THE CONSUMPTION OF DAIRY PATTERNS IN THE MEXICAN POPULATION. MEXICO, ENSANUT 2012, 2016 AND 2018

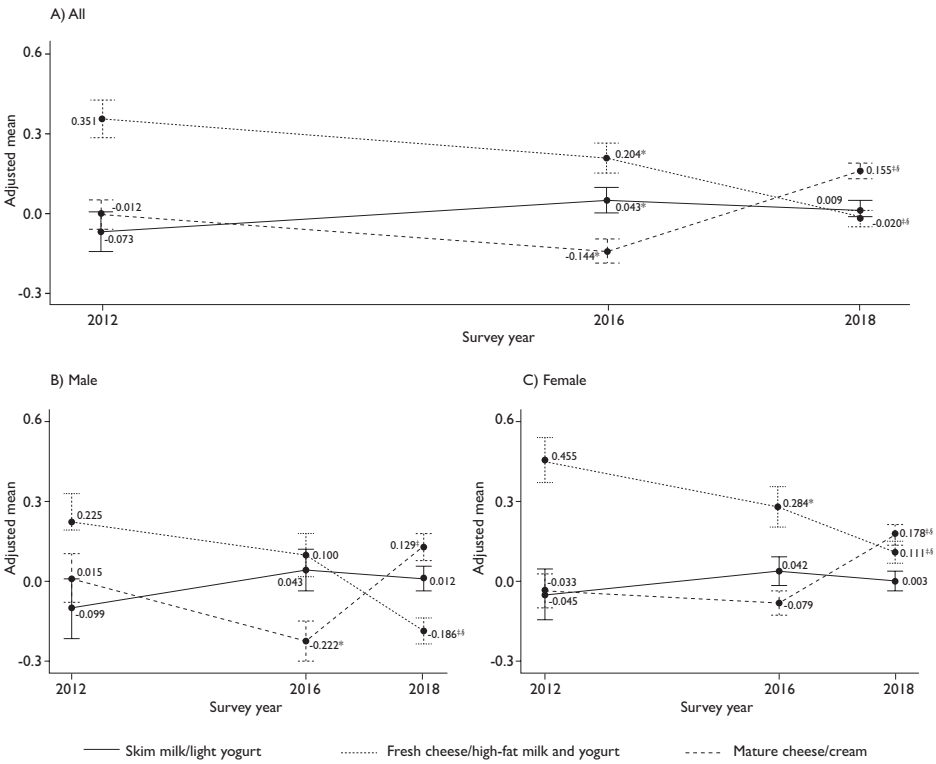
Characteristics	*Skim milk/light yogurt pattern*		*Fresh cheese/high-fat milk and yogurt pattern*		*Mature cheese/cream pattern*	
	Adjusted mean score	*95%CI*	*Adjusted mean score*	*95%CI*	*Adjusted mean score*	*95%CI*
Age (years)*						
20-30	-0.0632	-0.1166,-0.0099	0.2026	0.1342,0.2710	0.1047	0.0467,0.1627
31-40	-0.0093	-0.0700,0.0513	0.1281	0.0669,0.1894	0.0225	-0.0323,0.0774
41-50	0.0692	0.0117,0.1266	0.1088	0.0527,0.1649	-0.0080	-0.0579,0.0418
51-60	0.0669	-0.005,0.1387	0.1229	0.0638,0.1820	-0.0380	-0.0858,0.0098
61-70	0.0343	-0.0782,0.1467	0.1745	0.0885,0.2604	-0.0470	-0.1193,0.0254
≥70	-0.1757	-0.3014,-0.05	0.2265	0.0871,0.3659	-0.0338	-0.1151,0.0476
p for trend	0.742		0.947		<0.001	
Sex*						
Male	-0.0103	-0.0562,0.0356	0.0198	-0.0267,0.0662	-0.0114	-0.0526,0.0297
Female	0.0004	-0.0352,0.036	0.2641	0.2262,0.3020	0.0381	0.0100,0.0661
Education level‡						
None	-0.1504	-0.2399,-0.0609	0.0245	-0.1023,0.1514	-0.0362	-0.1271,0.0547
Elementary school or less	-0.0808	-0.1344,-0.0271	0.0356	-0.0188,0.0899	-0.0520	-0.0921,-0.0119
Middle school	-0.0136	-0.0629,0.0358	0.1240	0.0741,0.1740	0.0225	-0.0182,0.0633
High school	-0.0206	-0.0803,0.0391	0.2059	0.1385,0.2733	0.0768	0.0101,0.1436
College or beyond	0.2603	0.1428,0.3778	0.4741	0.3757,0.5725	0.1035	0.0271,0.1798
p for trend	<0.001		<0.001		<0.001	
Family socioeconomic level‡						
Low	-0.0125	-0.0534,0.0285	-0.0495	-0.0958,-0.0033	-0.0574	-0.0992,-0.0156
Middle	-0.0461	-0.0973,0.0051	0.1551	0.1019,0.2083	-0.0046	-0.0426,0.0333
High	0.0328	-0.0225,0.0882	0.2855	0.2280,0.3430	0.0784	0.0310,0.1259
p for trend	0.166		<0.001		<0.001	
Residence area§						
Rural	0.0139	-0.0428,0.0705	0.0814	0.0187,0.1442	-0.0798	-0.1259,-0.0336
Urban	-0.0096	-0.0430,0.0238	0.1764	0.1415,0.2112	0.0432	0.0145,0.0719
Region#,&						
North	0.0197	-0.0295,0.0689	0.0743	0.0293,0.1192	0.0217	-0.0226,0.0659
Center	-0.0638	-0.1151,-0.0125	0.1367	0.0882,0.1852	-0.0172	-0.0559,0.0214
Mexico City	-0.1092	-0.2013,-0.0172	0.4155	0.2998,0.5313	0.1390	0.0561,0.2218
South	0.0927	0.0357,0.1497	0.0980	0.0492,0.1468	-0.0266	-0.0732,0.0201
Personal history of						
Diabetes mellitus≠						
Yes vs. No	-0.0811	-0.1877,0.0255	0.2601	0.1673,0.3529	0.0339	-0.0426,0.1103

(continues…)

(continuation)

Hypertension[∞]						
Yes vs. No	-0.0119	-0.0617,0.0379	0.1482	0.0917,0.2046	0.0039	-0.0404;0.0482
Cardiovascular diseases[∞]						
Yes vs. No	-0.0762	-0.2514,0.099	0.2214	0.0053;0.4374	0.0435	-0.1325;0.2194
Body mass index (kg/m^2)[º]						
Normal weight	-0.0282	-0.0820,0.0256	0.1534	0.0952;0.2117	-0.0118	-0.0571;0.0334
Overweight	-0.0009	-0.0506,0.0487	0.1793	0.1310;0.2276	0.0303	-0.0124;0.0730
Obesity	0.0104	-0.0359,0.0568	0.1301	0.0815;0.1786	0.0218	-0.0172;0.0690
p for trend	0.286		0.485		0.320	

Statistically significant differences are highlighted in bold. A Bonferroni test was performed for multiple comparisons
[*] Adjusted by survey year. Sex and age were adjusted simultaneously
[‡] Adjusted by survey year, age, sex, and region. Education and socioeconomic level were adjusted simultaneously
[§] Adjusted by survey year, age, sex, region and socioeconomic level
[#] North: Baja California, Baja California Sur, Coahuila, Chihuahua, Durango, Nuevo León, San Luis Potosí, Sinaloa, Sonora, Tamaulipas, and Zacatecas; Center: Aguascalientes, Colima, Guanajuato, Hidalgo, Jalisco, Michoacán, Nayarit, Querétaro, Morelos, and State of Mexico; Mexico City and surrounding municipalities from State of Mexico; South: Campeche, Chiapas, Guerrero, Oaxaca, Puebla, Tlaxcala, Quintana Roo, Tabasco, Veracruz, and Yucatán.
[&] Adjusted by survey year, age, sex, and sociodemographic level
[≠] Adjusted by survey year, age, sex, education level, sociodemographic level, region, and BMI
[∞] Adjusted by survey year, age, sex, education level, sociodemographic level, region, BMI, and diabetes
[º] Adjusted by survey year, age, sex, education level, sociodemographic level, and region
Ensanut: *Encuesta Nacional de Salud y Nutrición*



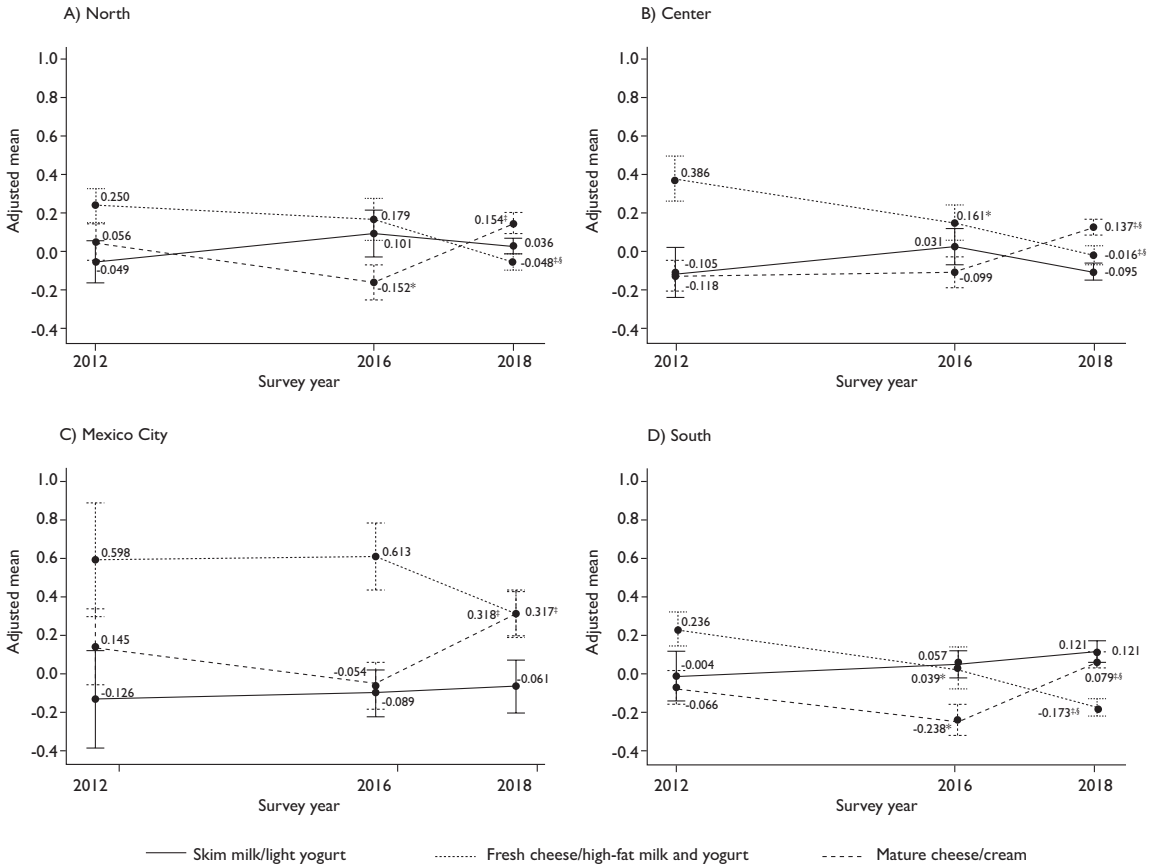
[*] Statistical differences in adjusted mean scores between 2016 and 2012
[‡] Statistical differences in adjusted mean scores between 2018 and 2012
[§] Statistical differences in adjusted mean scores between 2018 and 2016

Figure 1. Changes over time in dairy consumption patterns among Mexican adults among gender. Mexico, Ensanut 2012, 2016 and 2018

average consumption of "skim milk/light yogurt" and "mature cheese/cream" increased in all regions. Unlike the skim pattern, the mature cheese pattern increased mainly among women. In contrast, the consumption of "fresh cheese/high-fat milk and yogurt" pattern decreased steadily in all regions without differences by sex.

Compared with other studies that used dairy patterns, there are similarities and differences. In agreement with our results, two of them[11,12] reported two similar patterns: 1) whole milk and higher-fat dairy, and 2) reduced-fat dairy including yogurt. In the Irish study,[11] its third pattern with high consumption of butter and cream could be similar to the mature cheese/cream pattern described in this study. Regarding the Mexico City study,[13] that has two different patterns whose dairy (cheeses and yogurt) components are distributed between two of our patterns. These differences could be explained by the fact that only males with a mean age of 67 years and residents from Mexico City were included in the previous study, and its dietary questionnaire did not consider dairy products with different fat content. Differences in the number and composition of patterns among populations are feasible since dairy food intakes are influenced by sociocultural and economic factors, but also by the availability of products and processing methods.[26] The same explanation may be used for the highest consumption of "fresh cheese/high-fat milk and yogurt" observed among residents of Mexico City.

To date, there are no studies that evaluate trend changes in the consumption of dairy patterns over time; however, the changes observed during the study period are consistent with trends in dairy consumption observed over 11 years (1992-2003) among women and men 10-75 years old, in one region of Spain.[27] In that study, there was a remarkable increase in the consumption of yogurt (from 7 to 19 g/day) and low-fat milk



* Statistical differences in adjusted mean scores between 2016 and 2012
‡ Statistical differences in adjusted mean scores between 2018 and 2012
§ Statistical differences in adjusted mean scores between 2018 and 2016

Figure 2. Changes over time in dairy consumption patterns according to the region of residence. Mexico, Ensanut 2012, 2016 and 2018

(from 46 to 94 g/day), accompanied by a decrease in the consumption of whole milk.[27]

Unlike Ensanut 2012 and 2018, the 2016 survey was conducted between May and September, which could explain the observed decrease in the consumption trends of fresh cheese/high-fat milk and yogurt and mature cheese/cream patterns; however, the trend of the first pattern is maintained over time. Meanwhile, the consumption of the latter pattern increases, but as we know, there is no evidence that cheese consumption varies seasonally. In contrast, we do not rule out that the increase in consumption of the skim milk/light yogurt pattern could be a consequence of the tax on sugar-sweetened beverages implemented in 2014. As the observed increase in water consumption,[28] a simulation study suggests that this tax could increase the consumption of milk by 8.4%.[29]

Changes in food choices over time might also occur, especially when health issues arise, and people modify their diet to make healthier choices.[30] Unlike other studies, we observed a higher consumption of fresh cheese/high-fat milk and yogurt among women. Dairy products are a good calcium source and might be consumed for preventing osteoporosis, a very common disease among peri and post-menopause women.[31] Additionally, the Irish study also observed that the pattern with a higher yogurt content was consumed more often by women.[11]

Regarding the strengths of this study, it should be noted that this is a nationally representative study that included a validated food-frequency questionnaire[19] and contained the dairy products commonly consumed in Mexico. Additionally, our approach to identify dietary patterns is realistic and effective for analyzing complex dietary behaviors. Since our objective was not to compare absolute dairy consumption but rather to reflect how individuals consume dairy products collectively, PCA accounts for correlations between foods, assigns continuous scores representing adherence to multiple patterns, and allows individuals to exhibit varying intensities of these patterns. Nevertheless, some limitations must be considered. We did not reject the possibility that the number of patterns and the frequency of some observed patterns could be underestimated. Traditional Mexican dishes such as "*antojitos*" and "*atole*" included cheese and milk and we did not consider those recipes; however, the frequency of atole with milk consumption was less than 1% in all surveys. The low frequency of consumption of some yogurt varieties did not allow us to generate subcategories. We did not evaluate an extended trend. Ensanut 2020 and 2021 were not included because the dietary habits of the population could be affected by the Covid-19 pandemic. We do not reject that the observed association between "fresh cheese/high-fat milk and yogurt" pattern consumption and T2D, could be consequences of reverse causality or residual confounding. Our analysis is based on three cross-sectional studies without differentiation by T2D severity or duration. Additionally, we did not adjust by other potential dietary confounders. Finally, the questionnaire did not include questions about the real motives for choosing each dairy. For this reason, we do not know whether the identified patterns respond to a real preference or are conditioned by economic accessibility.

There is consistent evidence about the health benefits of dairy consumption,[32-35] mainly preventing metabolic chronic diseases highly prevalent in our population. The health effects of dairy food may vary depending on the predominant dairy consumption pattern. This approach might help to elucidate potentially synergistic health effects from dairy foods that might not be captured by "total dairy" alone. The sum of all dairy products' intakes or evaluating them according to their fat content, incorrectly assumes that people consume all types of dairy and that all dairy foods have a homogeneous and additive matrix effect. In addition, the intake of individual dairy does not reflect the overall form of consuming these products.

In conclusion, this study supports the existence of different population-specific dairy consumption patterns and their changes over time. These findings suggest that the traditional assessments of dairy consumption might not be the best approach to capture their potential health effects. To evaluate the variation of dairy intake patterns throughout life and over time is also necessary.

Declaration of conflict of interests. The authors declare that they have no conflict of interests.

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