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Obesity and central adiposity in Mexican adults: results from the Mexican National Health and Nutrition Survey 2006

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Abstract

Objective. To estimate the prevalence of overweight, obesity and central adiposity in Mexico, and to explore trends compared to the previous Mexican National Health Survey (ENSA 2000) and to Mexican-Americans**. Material and Methods.** The Mexican National Health and Nutrition Survey 2006 (ENSANUT 2006) was used to describe overweight, obesity and central adiposity. Trends over time were assessed using the ENSA 2000 and by comparing the ENSANUT 2006 results to those of Mexican-Americans using the United States National Health and Nutrition Examination Survey (NHANES) 1999-2000 and 2005-2006. **Results**. A total of 33 023 adults ≥ 20 years old were included; 39.7% were found to be overweight and 29.9% were found to be obese; 75.9% of all adults had abdominal obesity. In Mexico between 2000 and 2006, the combined prevalence of overweight and obesity in adults increased approximately 12%. Mexican-Americans showed a higher prevalence of morbid obesity compared to native Mexicans. **Conclusions**. Mexico has experienced a rapid increase in the number of adults who have experienced excess weight gain between the years 2000 and 2006.

Key words: obesity; body weight; health survey; cross-sectional studies; Mexico

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Resumen

Objetivo. Estimar la prevalencia de sobrepeso, obesidad y adiposidad central en México, y explorar las tendencias, comparándola con la Encuesta Nacional de Salud 2000 (ENSA 2000) y con los mexicano-americanos. **Material y métodos.** La Encuesta Nacional de Salud y Nutrición 2006 (ENSANUT 2006) fue usada para describir la prevalencia de sobrepeso y obesidad, asi como de adiposidad central. Las tendencias a través del tiempo fueron obtenidas usando la ENSA 2000, y se compararon con datos de la ENSANUT 2006 y con mexicano-americanos participantes de las National Health and Nutrition Examination Survey (NHANES) 1999-2000 y 2005-2006 de EUA. **Resultados**. De un total de 33 023 adultos ≥ 20 años de edad, 39.7% tuvo sobrepeso y 29.9% obesidad. El 75.9% tuvo obesidad abdominal. En México, entre 2000 y 2006 la prevalencia combinada de sobrepeso y obesidad incrementó ~12%. Los mexicano-americanos mostraron una mayor prevalencia de obesidad mórbida comparada con los mexicanos residentes en México. **Conclusiones**. México ha experimentado entre los años 2000 y 2006 un rápido incremento en el número de adultos que padecen sobrepeso.

Palabras clave: obesidad; peso corporal; encuesta de salud; estudio transversal; México

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Mexico is currently facing an obesity epidemic that is associated with rapid changes in socio-economic conditions and lifestyles. The emergence of excess weight gain as a significant public health problem in Mexico had been previously identified among adult females surveyed by the Mexican Nutrition Surveys I (1988)[1] and II (1999)[2] and by the Mexican Chronic Diseases Survey (1994).[3] When data for the second Mexican Nutrition Survey (1999) and the third Mexican Health Survey (2000)[4] were collected, a dramatic increase in the prevalences of obesity and overweight was documented.[5,6] The significant prevalence of overweight and obesity that is now evident among both male and female Mexican adults has previously been found to be associated with concomitant increases in the prevalences of many non-communicable, nutrition-related chronic diseases (NRCD) throughout Mexico, such as hypertension, type 2 diabetes, and dyslipidemia.[7-9] At present, the main causes of adult mortality in Mexico are cardiovascular diseases (CVD) and type 2 diabetes; both are associated with overweight and obesity and indicative of the epidemiologic transition that is taking place in Mexico. Although there are diverse pathophysiological mechanisms behind the myriad associations between excess weight gain and NRCDs, it is well recognized that being overweight or obese produces low-intensity chronic inflammation, a condition that damages a number of organs and systems. Moreover, low-intensity chronic inflammation and its relationship to obesity has been documented in the Mexican population.[10] Abdominal obesity, an indicator of cardio and/or metabolic disease risk, may be a more accurate predictor of NRCD risk than excess weight gain evaluated using body mass index.[11-16] Previous reports have described a number of characteristics of the epidemiologic transition in Mexico, such as: a) an overall rapid increase in obesity and chronic diseases with a slow decrease of undernutrition and infectious diseases;[6,9] b) a phenomenon of *polarization* across the country, in which the more developed northern region and a number of states are experiencing a different transitional stage marked by a higher burden of chronic diseases compared to the southern region, where there is still undernutrition and higher rates of infectious diseases,[12] and c) a rapid increase in obesity, chronic disease incidence and mortality in the least developed areas of the country (for example, in the southern region diabetes mellitus mortality increased 92.3% from 1980 to 2000 compared to 24.5% in the northern region during the same period).[9,17] Thus, it is suggested that the least developed areas in Mexico are rapidly catching-up to the chronic disease prevalence in the rest of the country; this could be described as a phenomenon of *homogenization* of the epidemiologic transition. According to epidemiologic and nutrition transition theories, at some point in a country's development, the more affluent population will become healthier due to better access to information, health services and overall quality of life.[18-20] To date, there has been no clear evidence of this shift occurring in Mexico. In addition, the observed prevalence of obesity in Mexican-Americans, which was higher during 2000, suggests that an increasing trend could persist in the coming years in Mexico.[21]

The objectives of this study were two-fold: a) to document the prevalence of overweight, obesity and abdominal obesity in Mexico by sex, age group, and sociodemographic factors (region, urban/rural area, socioeconomic status -SES- tertiles) and b) to explore the trends in obesity compared to the previous Mexican Health Survey (ENSA 2000) and to the Mexican-American population living in the United States using the National Health and Nutrition Examination Survey (NHANES) (1999-2000 and 2005-2006).

Material and Methods

The Mexican National Health and Nutrition Survey 2006 (ENSANUT 2006) was designed to obtain information on the health and nutritional status of the Mexican population based on a nationally representative sample. The adult questionnaire included self-reported responses to questions such as household expenditures on health services, use of preventive programs, use of health services and programs, disease presence (e.g. obesity, depression, accidents, type 2 diabetes, hypertension, cardiovascular disease) and disease risk factors (e.g. tobacco and alcohol consumption). The ENSANUT 2006 collected information from both men and women of all ages.

The ENSANUT 2006 is a nationally representative cross-sectional, multi-stage, stratified cluster sampling survey conducted between October 2005 and May 2006. It was constructed with sufficient sampling power to disaggregate the study sample into urban (population ≥ 2 500 inhabitants) and rural (population < 2 500 inhabitants) areas by state.

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 prevalence of 8.1% was considered at the state level. A maximum relative error rate of 25% was set for the state estimators, with a 95% confidence level, and accounted for a non-response rate of 20% and a design effect of 1.7 based on the 1988 and 1999 Mexican nutrition surveys. A sample size of at least 1 476 households per state was obtained and a total of 48 600 households were considered for the survey. Survey questionnaires were administered

by trained health personnel. A detailed description of the sampling procedures and survey methodology has been published elsewhere.[22]

Anthropometry

Anthropometric measurements (weight, height and waist circumference) were obtained from adults 20 years and older through internationally accepted procedures (n= 33 784). Field personnel were trained and standardized using conventional and internationally accepted protocols. Weight was measured to the nearest 10g using an electronic scale (Tanita, Model 1583, Tokyo, Japan), and height to the nearest millimeter using a stadiometer with precision of 1 mm (Dynatop E1, Mexico City, Mexico). Body mass index (BMI kg/m^2) was calculated and the nutritional status of survey participants was determined based on their BMI and WHO cutoff points: normal BMI 18.5 – 24.9 kg/m^2; overweight BMI 25-29.9 kg/m^2; obesity ≥ 30 kg/m^2 (in addition, obesity was divided by type I (30-34.9), type II (35-39.9) and type III or morbid obesity (> 39.9 kg/m^2).[23] Abdominal obesity was classified by a waist circumference ≥ 90 cm in males and ≥ 80 cm in females, according to the International Diabetes Federation (IDF) criteria.[24] Subjects with low weight (BMI < 18.5kg/m2) (n= 428, or 1.27% of the sample) and pregnant women (n= 416, or 1.23% of the sample) were excluded from this study. Those with aberrant or incomplete data (n= 345, or 1.02% of the sample) were also excluded from this study.

Regionalization of the country

The ENSANUT 2006 is representative of the four regions in Mexico: north, central, Mexico City and south. These four regions, with common geographic and socioeconomic characteristics, are made up of the following states: a) north: Baja California, Southern Baja California, Coahuila, Durango, Nuevo Leon, Sonora, Sinaloa, Tamaulipas and Zacatecas, b) central: Aguascalientes, Colima, Guanajuato, Hidalgo, Jalisco, Mexico, Michoacan, Nayarit, Querétaro, San Luis Potosí and Tlaxcala, (3) Mexico City and (4) south: Campeche, Chiapas, Guerrero, Morelos, Oaxaca, Puebla, Quintana Roo, Tabasco, Veracruz and Yucatan. This regionalization scheme has been used in previous epidemiologic studies to make within-country comparisons.[12, 17]

Configuration of socioeconomic status index

Collected socioeconomic information on household conditions (flooring material, roof material, wall material, number of persons residing in the household), basic household infrastructure (water source and disposal) and number of household domestic appliances (radio, television, and refrigerator) was used to construct a SES index. Principal component analysis (PCA) was used to construct this SES index based on a methodology previously reported in the first National Nutrition Survey (1998).[25-27] From this analysis, the primary principal component explained 42% of the variability among households with respect to the variables indicative of SES that were included in the PCA. The factors had large loadings for the variables related to household infrastructure, such as sewer system and indoor plumbing. The principal component for SES was then used to divide households into natural SES tertiles (low, medium, high).

Statistical analysis

Sociodemographic and health characteristics (sex, age group, region, area, SES tertile, and education level) were described for the complete sample and across BMI categories. The mean BMI (kg/m^2) and waist circumference were estimated for the total population and by sex, age group, region, rural/urban area, SES tertile and education level. The prevalence of abdominal obesity was estimated by state and ranked by order of magnitude; these estimates and rankings were further stratified by rural and urban area (with the exception of the entire Mexico City area, which is only urban). We compared the prevalence of obesity estimated from the ENSANUT 2006 with that estimated from the 2000 Mexican Health Survey (ENSA), and compared these two estimated prevalences of obesity with that of Mexicans living in United States, stratified by foreign and United States born Mexicans (Mexican-Americans), using NHANES 1999-2000 and 2005-2006.[28] All calculations were adjusted for the complex survey design using the SVY module in STATA version 9 (College Station, TX, USA).* A p-value < 0.05 was used to assess statistical significance.

Ethical considerations

All participants signed an informed consent prior to the survey interview. The ENSANUT 2006 and the written consent form were approved by the Ethics Committee of the National Institute of Public Health (INSP).

* Stata Corp. Stata reference manual. Release 7, vol. 1-4. College Station, (TX): Stata Press, 2001.

Results

After excluding underweight individuals, pregnant women, and participants with aberrant or incomplete data, the final study sample consisted of 32 595 male and female adults ≥ 20 years of age (58.2% females). The descriptive characteristics of the analytic sample are presented in Table I. From this sample, 39.7% of the adults were classified as overweight and 29.9% were classified as obese. Based on the sex-specific waist circumference criteria to define abdominal obesity, 75.9% of the adults were found to have abdominal obesity; 84.2% of females and 63.4% of males (data not shown).

The prevalence of obesity was higher in women (36.9%) than in men (23.5%), however overweight plus obesity was only 6.3% higher in women (Table I). Among both sexes, by age group, the 50-59 years age group had the highest prevalence of obesity (38.5%), followed by the 40-49 years group (37.1%) (Table I). Adults aged 20-29 years had the greatest percentage of normal BMI (44.2%)

Table I
CHARACTERISTICS OF ADULTS ≥ 20 YEARS OLD FROM THE ENSANUT 2006*

	Total			*Body Mass Index‡*		
	Sample size	*Weighted Size*	*%*	*Normal 29.2% (n=9 266)*	*Overweight 39.7% (n=13 050)*	*Obese 29.9% (n=10 279)*
Sex						
Females	19 798	25 670 831	58.2	27.3#	36.9#	36.9#
Males	13 225	18 054 492	41.8	31.8	43.2	23.5
Age (years)						
20-29[a]	7 075	10 685 730	24.0	44.2[b,c,d,e]	34.1[b,c,d,e]	18.9[b,c,d,e]
30-39[b]	9 052	10 636 559	24.2	26.4[a,c,d,e]	42.1[a]	30.8[a,c,d,e]
40-49[c]	6 788	88 35 119	20.4	20.5[a,b,e]	41.8[a]	37.1[a,b,e]
50-59[d]	4 187	5 960 510	13.8	19.8[a,e]	41.0[a]	38.5[a,e]
≥ 60[e]	5 917	7 600 068	17.5	29.9[a,b,d]	39.8[a]	28.4[a,d]
Region						
North[a]	7 835	8 554 440	19.6	26.5[b,d]	37.1[b,c,d]	34.7[b,c,d]
Central[b]	1 ,651	16 910 880	38.7	28.7[a,d]	40.4[a]	29.5[a,d]
Mexico City[c]	925	4 231 073	9.7	27.4[d]	41.2[a]	30.2[a]
South[d]	11 612	14 028 930	32.0	31.9[a,c]	39.6[a]	27.3[a,b]
Location						
Rural	9 530	9 966 815	22.8	34.1#	39.3	24.8#
Urban	23 493	33 758 508	77.2	27.7	39.6	31.3
Socioeconomic status Tertile						
Low	12 740	14 128 439	32.3	34.2[b,c]	39.3	24.6[b,c]
Medium	11 431	14 797 070	34.0	26.1[a]	39.9	32.4[a]
High	8 713	14 588 221	33.7	27.4[a]	39.4	32.1[a]
Education						
Less than elementary	3 691	4 640 340	10.7	32.5[b]	38.8	26.6[b]
Elementary-secondary	16 176	20 381 975	46.8	25.7[a,c]	39.7	33.5[a,c]
More than high school	13 027	18 483 681	42.5	32.2[b]	39.6	26.7[b]
Abdominal obesity§	24 860	31 376 968	75.9	14.9	45.2	39.7

* Data adjusted for the complex survey design

‡ World Health Organization cutoff points. BMI normal = 18.5-24.9 kg/m^2, overweight 25.0-29.9 kg/m^2, obesity ≥ 30 kg/m^2

§ Abdominal obesity by International Diabetes Federation criteria (≥ 80 cm females, ≥ 90 cm males)

Differences were statistically significant between rural and urban locations

a,b,c,d,e: differences were statistically significant between categories

(Table I). When stratified by region, the north had the highest prevalence of obesity (34.7%) while the south had the lowest prevalence (27.3%) (Table I). The highest SES tertile had a 7.5% higher prevalence of obesity (32.1%) than the lowest SES tertile (24.6%) (Table I).

Table II shows mean BMI by age group and sociodemographic factors (region, rural/urban area, SES tertile, education level); all age groups had a mean BMI that was in the overweight or obese range. The northern region had the highest mean BMI, which was statistically significantly different from the other three regions in Mexico, that also had mean BMIs in the overweight range; mean BMI in urban areas was higher than that of rural areas ($p < 0.05$) (Table II). The lowest SES tertile had the lowest mean BMI when compared to the other two tertiles ($p < 0.05$) and there was a statistically significant difference between mean BMI of those with an education level of elementary school or less and those who had achieved an education level between elementary and secondary school (Table II). Furthermore, among all age groups, regions, rural/urban areas, and SES tertiles significant differences in mean BMI between women

Table II

MEAN BODY MASS INDEX BY AGE AND SOCIODEMOGRAPHIC FACTORS IN MEXICO, ENSANUT 2006*

	BMI (kg/m²)					
	TOTAL (n= 33 023)		Females (n= 19 798)		Males (n= 13 225)	
	Mean	SD	Mean	SD	Mean	SD
Mean BMI	27.9	5.2	28.4	5.5	27.1	4.6
Anthropometry						
Height (cm)	157.8	9.6	152.4	7.0	165.4	7.8
Weight (kg)	69.5	14.7	66.0	14.1	74.4	14.4
Age group (years)						
20-29[a]	26.0[b,c,d,e]	4.9	26.3	5.2	25.8	4.5
30-39[b]	28.2[a,c,d,e]	5.0	28.6	5.3	27.6	4.5
40-49[c]	29.0[a,e]	5.2	29.7	5.5	28.0	4.4
50-59[d]	29.1[a,b,e]	5.0	29.9	5.3	28.1	4.5
≥ 60[e]	27.6[a,b,c,d]	5.2	28.3	5.7	26.7	4.4
Region						
North[a]	28.5[b,c,d]	5.7	29.4	6.2	27.4	4.8
Central[b]	27.8[a,d]	5.1	28.3	5.3	27.1	4.5
Mexico City[c]	28.0[a,d]	5.0	28.5	5.4	27.6	4.3
South[d]	27.5[a,c]	5.0	27.9	5.3	26.9	4.5
Area						
Rural [a]	27.1[b]	5.0	27.7	5.3	26.3	4.3
Urban [b]	28.1[a]	5.2	28.6	5.6	27.4	4.6
Socioeconomic status tertile						
Low[a]	27.1[b,c]	5.0	27.7	5.3	26.3	4.4
Medium[b]	28.3[a]	5.3	28.9	5.6	27.4	4.6
High[c]	28.2[a]	5.2	28.6	5.6	27.6	4.5
Education level						
Less than elementary	27.3[b]	5.2	27.9	5.4	26.0	4.5
Elementary-secondary[b]	28.4[a]	5.3	29.1	5.3	27.2	4.5
More than high school[c]	27.5	5.2	27.8‡	5.5	27.2	4.6

* Data adjusted for the survey's complex design.

‡ Differences were statistically significant between females and males except where marked by this symbol

a,b,c,d,e. Differences were statistically significant between categories

BMI: body mass index

SD= Standard deviation

and men were observed, such that among each of those sociodemographic categories women had a higher mean BMI than men (Table II). When the Mexican population is characterized by mean waist circumference (WC) (Table III) the trends in mean WC by age group, region and rural/urban area are similar to those seen in Table II, where the population is examined by mean BMI. Thus, irrespective of one's age group or the regional or rural/urban area in which they live, on average both men and women in Mexico have abdominal obesity, as determined by the IDF criteria (Table III). Table III also indicates that women may have a greater amount of fat as abdominal fat than men, as the mean WC for women is much higher than the sex-specific cutoff point for abdominal obesity (≥ 80 cm) as compared to men. There also appears to be a differential trend by education level between men and women, such that the highest education level (more than high school) was associated with the highest WC in men and the lowest WC in women (Table III).

When prevalence of abdominal obesity is analyzed by state, the lowest prevalence of abdominal obesity was observed in the southern state of Oaxaca (61.4%) and the highest prevalence of abdominal obesity was observed in the northern state of Tamaulipas (82.9%); that is, prevalence of abdominal obesity in Tamaulipas was 35% higher than in Oaxaca (Figure 1).

When the mean BMI estimated from this study sample was compared with that from the 2000 Mexican Health Survey (ENSA), the prevalence of excess

Table III

MEAN WAIST CIRCUMFERENCE* BY AGE GROUP AND SOCIODEMOGRAPHIC FACTORS IN MEXICO, ENSANUT 2006

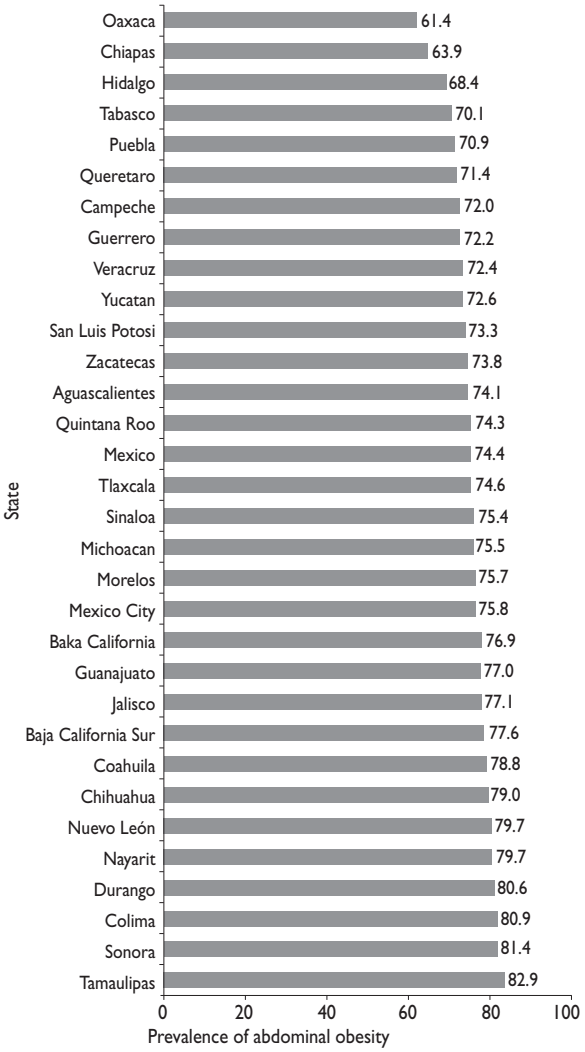
	Waist circumference					
	Total (*n*= 32 174)		*Females* (*n*= 19 501)		*Males* (*n*= 12 673)	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Mean waist circumference	93.7	13.1	93.1	13.6	94.5	12.2
Age group (years)						
20-29[a]	87.9[b,c,d,e]	12.8	87.0	13.0	89.4	12.4
30-39[b]	92.7[a,c,d,e]	12.4	91.7	12.7	94.2	11.8
40-49[c]	95.5[a,b,d,e]	12.5	94.9‡	13.3	96.4	11.2
50-59[d]	97.6[a,c,c]	12.5	97.3‡	12.5	98.0	12.5
≥ 60[e]	97.1[a,b,c]	12.7	97.9	13.6	96.1	11.3
Region						
North[a]	96.5[b,c,d]	14.0	96.3‡	14.5	96.9	13.3
Central[b]	93.8[a,d]	13.0	93.1	13.6	94.7	12.0
Mexico City[c]	93.6[a,d]	12.7	93.0‡	13.5	94.5	11.6
South[d]	91.8[a,c]	12.4	91.1	12.8	92.8	11.7
Area						
Rural[a]	91.9[b]	12.8	91.7‡	13.2	92.3	12.1
Urban[b]	94.2[a]	13.1	93.5	13.7	95.2	12.1
Socioeconomic status tertile						
Low[a]	91.9[a,c]	12.6	91.8‡	13.2	91.9	11.6
Medium[b]	94.8[b]	13.2	94.4	13.9	95.2	12.2
High[c]	94.3[a]	13.2	92.8	13.7	96.3	12.2
Education level						
Less than elementary	94.5[c]	13.0	95.1	13.4	93.2	12.2
Secondary or less[b]	94.9[c]	12.8	94.8‡	13.2	95.1	12.0
More than high school[c]	92.0[a,b]	13.0	90.0	13.1	94.3	12.6

* Data adjusted for the survey's complex design. Excluded pregnant women

‡ Differences were statistically significant between females and males except where marked by this symbol

a,b,c,d,e: differences were statistically significant between categories

SD= Standard deviation



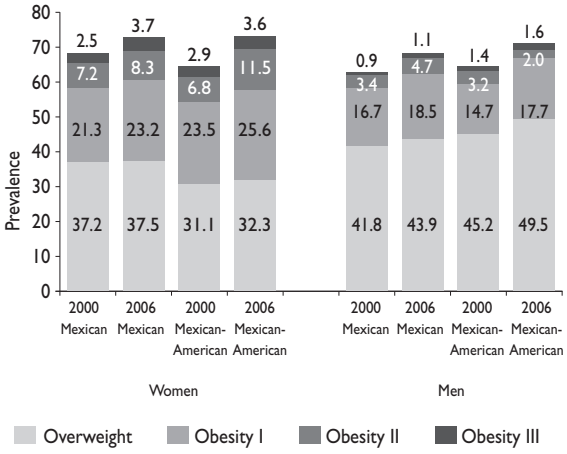
* Data adjusted for the survey complex design. Excluded pregnant women

FIGURE 1. PREVALENCE OF ABDOMINAL OBESITY IN ADULTS ≥ 20 YEARS OLD BY STATE. ENSANUT 2006*

weight gain (BMI ≥ 25 kg/m^2) among adults in Mexico increased by about 12 percent. The prevalence of Type III obesity, or morbid obesity, also increased in females by 48% (from 2.5% to 3.7%) over this same time period. In males, the prevalence of overweight was higher, but the prevalence of obesity was lower when compared to that of females in both 2000 and 2006. In 2000, the prevalence of excess weight gain (BMI ≥ 25 kg/m^2) for Mexican-American females was similar to that of Mexican women, however they had a 16% higher prevalence of morbid obesity (2.5 *vs* 2.9%, respectively), whereas in 2006, the prevalence of morbid obesity among Mexican-American women and those living in Mexico was similar. In 2000, Mexican-American males had a 2.7% higher prevalence of excess weight gain (BMI > 25 kg/m^2) than those in Mexico (64.5% *vs* 62.8%, respectively); in 2006, this difference was to 1.5% (66.7 *vs* 68.2%, respectively) (Figure 2).

Discussion

Based on the nationally representative ENSANUT 2006 survey, this study describes the prevalence of measures of excess weight gain, as classified by body mass index and waist circumference, among Mexican adults aged ≥ 20 years. This study also evaluates, for the first time, the trends over time between 2000 and 2006 among both Mexican and Mexican-American adults. Our results show that for Mexican adults the prevalence of overweight and obesity increased greatly between 2000 and 2006. Although substantial economic development has taken place in Mexico over this time period that is related to an emerging nutrition transition in Mexico (often associated with those with lower incomes able to increase their dietary intake of high-energy dense foods),



* BMI, kg/m^2, range: overweight 25.0-29.9; obesity class I 30.0-34.9; obesity class II 35.0-39.9; obesity class III ≥ 40.0

Source: ENSA 2000, ENSANUT 2006, NHANES (1999-2000 and 2005-06)

FIGURE 2. CHANGES IN THE PREVALENCE OF OVERWEIGHT AND OBESITY* IN MEXICAN ADULTS (ENSA 2000 AND ENSANUT 2006)

a positive relationship between income and obesity is still observed in Mexico. However, this study indicates that differences in the prevalence of excess weight gain between the most developed region (north) and the least developed region (south) are currently small; on average, people in all regions appear to be overweight according to mean body mass index. Moreover, we found that among all age groups, regions, rural/urban areas, and SES tertiles women had a higher mean BMI that was statistically significantly different from that of men. Thus, it may be necessary to develop gender-specific programs aimed at excess weight gain prevention.

While it appears that income continues to be positively associated with obesity among adults of both sexes in Mexico, the relationship between education level and obesity appears to differ by sex. This study found that women with the highest education level (bachelors degree or more) had the lowest mean waist circumference and, therefore, the lowest prevalence of abdominal obesity, whereas men who had obtained the highest education level had the highest mean waist circumference and prevalence of abdominal obesity when compared to men with other education levels. This opposite relationship for men versus women between abdominal obesity and education level reflects an important sex-specific obesity risk pattern that must be carefully considered by preventive programs. Moreover, this finding could represent the beginning of a shift in which lower income also is positively associated with obesity, particularly among men, as is often observed in developed countries as well as other developing countries that are also undergoing a nutrition transition. When abdominal obesity was analyzed by state, all states had a prevalence of abdominal obesity over 50 percent. However, an important difference between states was evident. Tamaulipas in the northern region had the highest prevalence (82.9%), while Oaxaca, in the south and the least developed region, had the lowest prevalence (61.4%), reflecting a similar positive relationship between obesity prevalence and income, albeit in the form of economic and infrastructural development.

While the results from this study show that both overweight and abdominal obesity increased, it is well known that excess weight gain is the most important modifiable risk factor for nutrition-related chronic diseases.

The comparison of trends over time in the prevalence of overweight between Mexicans and Mexican-Americans is important for a number of reasons. First, while adults in Mexico and Mexican-Americans are relatively from the same ethnic group, they are exposed to different social and physical environments (e.g. access to food, health services, health information, education, environment, and physical activity opportunities), and thus different risk factors for weight gain and NRCDs. Also, Mexico and the United States are at different stages in the epidemiologic transition; in the US, as in many other developed countries, those of the lowest socioeconomic strata have the highest prevalence of obesity, such that Mexican-Americans living in the US have the second highest prevalence of obesity among all ethnic groups in that country. For both Mexican-Americans and Mexicans there is currently a higher prevalence of overweight among men than women. However, a striking contrast between overweight and obesity prevalences for Mexican-Americans as compared to Mexicans is sex-specific prevalence differences within these two countries. We found that among Mexican-Americans, men have a higher combined prevalence of overweight and obesity compared to women, whereas in Mexico, women have a slightly higher combined prevalence of overweight and obesity compared to men. We also show that, in Mexico, those among the highest socioeconomic strata as well as those living in the most developed northern region have the highest prevalence of obesity in the country.

As characterized by our study, both the increased and high prevalence of excess weight gain (overweight, obesity, and abdominal obesity) that have occurred since 2000 and that currently exist among Mexican adults are substantial. A combination of factors have been identified as possible explanations for these changes, including urbanization, greater access to inexpensive kilocalories, decreased opportunities for physical activity, high-energy diets, increased consumption of caloric beverages, lack of adequate overweight and obesity prevention programs, and information regarding excess weight gain and its consequences.[9,29,30] We believe a comprehensive, organized social response is necessary to effectively address overweight and obesity, such as: a review of government food and nutrition programs that were originally designed to address undernutrition; improvement of the school environment to promote physical activity and regulation of children's consumption of high-energy foods and beverages and food marketing to children; prevention and screening for obesity and its associated NRCDs; and more adequate treatment, as well as access to treatment, to prevent chronic disease complications. It remains to be seen if the prevalence of excess weight gain will continue to increase in the least developed regions and if over future years, intensive prevention efforts, increased access to health services, and greater education and information about excess weight gain and its health consequences will contribute to a slow-down of the increasing prevalence of excess

weight gain among adults in Mexico –a condition that is likely related to the primary causes of adult mortality (CVD and type 2 diabetes) in the country.

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