Trends for type 2 diabetes and other cardiovascular risk factors in Mexico from 1993-2006

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Abstract

Objective. To describe the trends in the prevalence of type 2 diabetes (T2D), and other cardiovascular risk factors in three national health surveys (1993, 2000 and 2006). **Materials and Methods.** The databases of three surveys: ENEC 1993, ENSA 2000 and ENSANUT 2006 were gathered. Calculations of published data were reprocessed to do appropriate adjustments to assure comparability among surveys. **Results.** From 1993 to 2006 the prevalence of type 2 diabetes (6.7-14.4%), metabolic syndrome (26.6-36.8%), hypertension (23.8-30.7%), hypercholesterolemia (27-43.6%), and high LDL-cholesterol (31.6-46%) increased rapidly. The prevalence of low HDL cholesterol was very high (60.5-63%) in all surveys and remained remarkably unchanged among surveys. **Conclusions.** This increasing trends for the prevalence of T2D and cardiovascular risk factors predicts larger increments in the near future for T2D and cardiovascular morbidity and mortality. Intensification of the preventive and remedy strategies is mandatory in order curve the foreseen dramatic increment in the disease burden.

Key words: type 2 diabetes; hypertension; dyslipidemias; chronic non-transmissible diseases; national surveys; Mexico

Resumen

Objetivo. Describir las tendencias en la prevalencia de diabetes tipo 2 (T2D), y otros factores de riesgo cardiovascular como las dislipidemias y la hipertensión en tres encuestas nacionales de salud (1993, 2000 y 2006). **Material y Métodos.** Las bases de datos de ENEC 1993, ENSA 2000 y ENSANUT 2006 fueron reprocesados para asegurar la comparabilidad entre las encuestas. **Resultados.** Entre 1993 y 2006 la prevalencia de T2D (6.7-14.4%), síndrome metabólico (26.6-36.8%), hipertensión (23.8-30.7%), hipercolesterolemia (27-43.6%), y LDL-colesterol alto (31.6-46%) aumentaron rápidamente. La prevalencia de concentraciones bajas de HDL-colesterol fue muy alta (60.5-63%) en todas las encuestas, manteniéndose esencialmente sin cambios. **Conclusión.** La tendencias crecientes en las prevalencias de T2D y factores de riesgo cardiovascular predicen que a corto plazo habrá importantes incrementos en la morbilidad y mortalidad asociada a la T2D y enfermedades cardiovasculares, por lo que deben intensificarse las estrategias para prevenir y reducir los incrementos dramáticos previstos en la carga de enfermedad.

Palabras clave: diabetes tipo 2; hipertensión; dislipidemias; enfermedades crónicas no transmisibles; encuestas nacionales; México

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The epidemiological profile has changed dramatically in Mexico over the past three decades. The principle causes of morbidity and mortality have transitioned from a scenario dominated by infectious diseases to one with a predominance of chronic non-transmissible diseases.[1]

A series of dietary and lifestyle changes in Mexico have been associated to increments in the prevalence of obesity and cardiovascular disease.[2] The most noticeable change in the last three decades is a larger intake of energy-dense foods accounting for increments of 24% in calories and 30% in lipids relative to the daily energy intakes.[3]

The mortality associated with diabetes mellitus increased from a rate of 48/100 000 inhabitants in 1980 to 73/100 000 in the year 2000. Diabetes has become the primary cause of death in Mexican adults.[4] The national budget for diabetes, cardiovascular diseases and obesity – related expenses was calculated in 2006 to be 39 911 million of Mexican pesos. This quantity equals 7% of the national expenditure in health and 0.4% of the gross domestic product. Most of this expenditure (73%) was financed by the public sector.[5]

In addition, cardiovascular mortality has also increased importantly in Mexico; it is the second most frequent cause of mortality in adults.[6]

The evolving epidemiology of chronic non-transmissible diseases has been documented in a series of national probabilistic surveys since 1993: the National Survey of Chronic Diseases 1993 (ENEC 1993),[7] the National Health Survey 2000 (ENSA 2000)[8] and the National Health and Nutrition Survey 2006 (ENSANUT 2006).[9] Additional articles analyzing data on chronic non-transmissible diseases derived from ENSANUT 2006 are published in this issue of *Salud Pública de México*.

This article aims to describe the trends in the prevalence of type 2 diabetes (T2D), dyslipidemia and hypertension over the time elapsed from the first to the last of the three national health surveys (1993-2006). This analysis is intended to provide useful information for the development of policies and strategies to control the overwhelming epidemic of non-transmissible chronic diseases.

Material and Methods

We gathered the databases of the three surveys: ENEC 1993, ENSA 2000 and ENSANUT 2006.[7-9] Calculations were reprocessed to assure comparability among surveys. Calculations to answer the new questions were then made, adjusting for the complex multistage sample design [using the "SVY" module of Stata 8.2 (College Station, TX, USA)], and weighting for the total samples. The differences between survey samples were analyzed comparing the prevalence and 95% confidence intervals (95% CI) or means and 95% CI of the relevant variables. The distribution by age and sex of adults 20 to 69 years old, living in locations greater than 2 500 inhabitants among the samples of three national surveys were not different, having the distributions of the ENEC 1993 as comparison group.

Trends in type 2 diabetes

T2D was defined if subject had a previous diagnosis by a physician or was diagnosed as a findings of the survey (fasting plasma glucose equal or greater than 126 mg/dl).[7] The same definitions applied for all three surveys; in addition the ENEC 1993 and ENSA 2000 included in the definition of T2D those with a random blood glucose > 200 mg/dL for all non-fasting subjects.

There was a significant increase in the prevalence of T2D over the period of 13 year examined in these analyses. The prevalence of T2D in the ENEC 1993 survey was 6.7% (previously diagnosed 4.6% and newly diagnosed 2.1%). The overall prevalence in the ENSA 2000 survey[10] was 7.5% (5.8% previously diagnosed [PD] and 1.7% newly diagnosed [ND]). In the ENSANUT 2006 survey, the prevalence reached 14.4% (7.3% PD and 7.1% ND).[11] The prevalence increased in both genders; the prevalence for women, was 6.8, 7.8 and 13.2% and for men 6.6, 7.2 and 15.8% in the 1993, 2000 and 2006 surveys, respectively. In both the ENSA 2000 and ENSANUT 2006, the prevalence was higher in urban (8.2 *vs.* 15.5% respectively) compared to rural populations (5.6 and 10.4% respectively).

The overall prevalence of T2D between 1993 and 2006 increased by two-fold [7.4 percentage points (p8)], resulting in a rate of 0.56 pp/year. If we consider only the PD cases, the prevalence increased from 4.6% in 1993 to 7.3% in 2006, representing an overall increment of 2.7 pp over a 13 year time period (0.2 pp/year). There are some reasons that can potentially explain the observed changes in the prevalence of diabetes. These include a shift in the age distribution of the population and a growing prevalence of obesity related to changes in lifestyle.[3]

In addition, there are several important methodological differences between surveys. The proportion of subjects studied under fasting conditions was small in both the 1993 and 2000 surveys (≈5%). As a result, most of the newly diagnosed cases were identified by the random blood glucose criterion. This characteristic of the 1993 and 2000 surveys may have led to an underestimation of the true prevalence; random glucose

measurements is the diagnostic criterion with the lowest sensitivity. This was not the case for the ENSANUT 2006 survey, fasting was verified, before blood sampling, in all participants. Another indicator of a possible underestimation of the T2D prevalence in the two earlier surveys is the proportion of previously diagnosed to newly diagnosed cases. This ratio was 1:0.45 for ENEC 1993, 1:0.26 for ENSA 2000 and 1:0.97 for ENSANUT 2006 respectively. For comparison, the PD:ND ratio in the National Health and Nutrition Examination Survey of North America (NHANES-III) was 1:0.5.[12]

Another probabilistic surveys[13,14] limited to low socioeconomic population living in Mexico City, reported a diabetes prevalence of 13.1% in 1996 and 13.8% in 2002. The NHANES-III survey reported a prevalence of 15.4% in the Hispanic population.[12]

Changes in early onset DM2

The high prevalence of T2D is associated with an onset at earlier age.[15] The prevalence of T2D diagnosed before 40 years of age increased progressively from 1.8% (PD= 1.04%, SF= 0.76%) in 1993,[16] 2.3% (PD=1.59%, SF=0.71%) in 2000[17] to 5.8% (PD=1.79%, SF=4.01%) in 2006. The surge of early onset T2D reported in ENSANUT 2006 corresponded predominantly to cases diagnosed during the survey (Figure 1).

Subjects diagnosed before 40 years of age will have a longer exposure to hyperglycemia and other diabetes-related abnormalities, increasing the likelihood of chronic complications.[18] Also, this type of T2D will require insulin therapy early on.[19] Studying this variant of the disease will render strategic information for health care planning in Mexico; detection campaigns and preventive actions have to be targeted, both, to subjects younger and older than 40 years.

Metabolic syndrome

The metabolic syndrome (MS) is a cluster of several cardio-metabolic risk factors, including abdominal obesity, hyperglycemia, dyslipidemia and elevated blood pressure.[20] In recent years, at least three definitions of the MS have been implemented: the National Cholesterol Education Program Adult Treatment Panel III (ATP III),[21] the ATP III definition modified by the American Heart Association; National Heart, Lung and Blood Institute (AHA / NHLBI),[20] and the International Diabetes Federation (IDF) definition focusing on central obesity.[22]

The MS has proven to be a useful teaching tool for practitioners and a marker for increased risk for type 2 diabetes[20,23,24] and cardiovascular disease.[25,26] In both, ENSA 2000 and ENSANUT 2006[27] pertaining
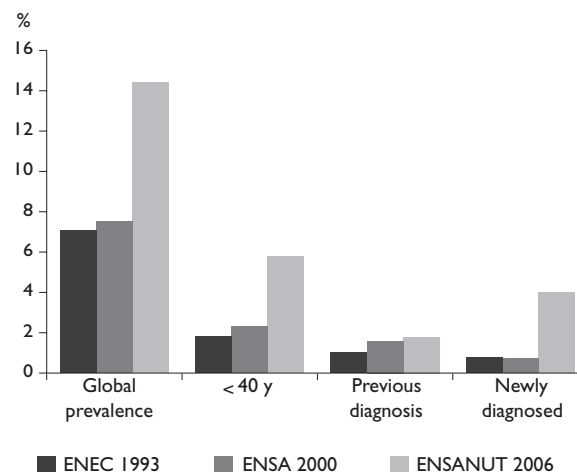
Figure 1. Prevalence of type 2 diabetes in subjects younger than 40 years of age from the National Chronic Diseases Survey 1993 (ENEC 1993), the National Health Survey 2000 (ENSA 2000) and the National Health and Nutrition Survey 2006 (ENSANUT 2006). The first set of bars represent the adjusted mean prevalence of type 2 diabetes in all-age groups. The second set represents the overall prevalence in subjects younger than 40 y of age, followed by two sets of bars for the prevalence stratified by previously diagnosed and newly diagnosed subjects

subsamples were selected (n=2 535, and 6 021 subjects, respectively) to study certain cardiovascular risk factors. These included fasting serum glucose, insulin, triglycerides, total cholesterol, and HDL-cholesterol. In both ENSA 2000 and ENSANUT 2006, the prevalence of T2D was higher in persons who also had other cardiovascular risk factors: 12.5 and 16.6 % with obesity; 11.2 and 18.9% with abdominal obesity; 12.6 and 19.5% with hypertension; 25.0 and 27.3% with hypercholesterolemia; 8.5 and 18.5% with hypertriglyceridemia; and 5.8 and 13.9% with low HDL cholesterol levels, respectively (Table I).

The age-adjusted prevalence of the MS according to the ATP III definition increased from 26.6% in 1993[28] to 34% in 2000 and 36.8% in 2006. A similar pattern was found using ATP III, AHA / NHLBI and IDF criteria; in 2000, 34%, 36.6%, and 29.3%, respectively, and in 2006, 36.8%, 41.6% and 49.8%, respectively.[27] The observed differences in the within survey prevalence are mainly due to differences in the waist circumference thresholds. Females and individuals older than 60 years were the most affected by this criterion, due in part, to the higher prevalence of central obesity in these groups

Table I

Comparison of the prevalence of the metabolic syndrome (MS) using three definitions: Results of the 2000 and 2006 Mexican national surveys

Definition of MS	ENSA 2000 (n=2 535 subjects)			ENSANUT 2006 (n=6 021 subjects)		
	ATP III 2001	AHA/NHLBI 2005	IDF 2005	ATP III 2001	AHA/NHLBI 2005	IDF 2005
Overall prevalence (%)	34.0	36.6	29.3	36.8	41.6	49.8
Sex (%)						
Male	24.1	26.5	23.4	30.3	34.7	46.4
Female	44.2	47.0	35.4	42.2	47.4	52.7
Age (%)						
20 to 39	23.5	25.5	17.5	23.8	27.9	36.0
40 to 59	53.7	58.2	50.7	50.0	56.2	64.9
60 and older	66.4	69.5	67.9	56.3	60.8	67.9
Locality size (%)						
Rural (less than 2 500 inhabitants	31.7	34.6	27.5	30.0	35.1	44.2
Urban (2 500 to 99 999 inhabitants)	39.9	42.6	32.5	37.7	42.8	50.9
Metropolitan area (100 000 and more inhabitants)	32.9	35.6	28.8	39.0	43.6	51.6

ENSA 2000= National Health Survey 2000[8]
ENSANUT 2006= National Health and Nutrition Survey 2006[9]
ATP III= National Cholesterol Education Program Adult Treatment Panel III
AHA/NHLBI= American Heart Association; National Heart, Lung and Blood Institute
IDF 2005= International Diabetes Federation

(Table II). The prevalence of Mexican adults fulfilling the MS definition increased at a rate of 0.77 pp/year from 1993 to 2006.

These data imply that the MS represents a significant burden to the Mexican health care system. The development of specific programs to treat diagnosed cases is urgently needed. If persons remain undiagnosed or untreated, there will be a considerable increment in the number of new T2D and CHD cases. This will result in a greater demand and expenditure on health care, as well as an overall increase in mortality.

Changes in the prevalence of lipid disorders

The assessment of the percentage of the population at cardiovascular risk due to an abnormal lipid profile is a continuous process. In the US and Europe, changes in environmental factors (diet, physical activity and alcohol intake), shifts in the age distribution of the population and the growing use of statins have modified the prevalence of lipid disorders.[29]

A description of the prevalence of lipid disorders was included in all three nationwide population-based health surveys.[7,30,31] The size of the population studied was 2 256 in the ENEC 1993 survey and 6 021 in the ENSANUT 2006 survey (Table II). No difference existed in the inclusion and exclusion criteria between studies. The demographic characteristics were similar between the selected subsamples and the entire population in the three reports. Some methodological differences may limit our ability to make crude comparisons between the studies. The laboratory reagents used for the quantification of the plasma lipids were not the same. Furthermore, additional precautions were applied to assure the fasting conditions of the participants in the ENSANUT 2006 survey.

The mean concentration of plasma lipids reported in ENEC 1993, ENSA 2000 and ENSANUT 2006 are shown in table II. An increment in the total cholesterol concentration occurred between 1994 and 2000. This elevation was greater in women (from 171 to 202.9 mg/dl) than in men (from 178 to 193 mg/dl). The same pattern was

Table II

Lipid disorders in Mexico: Comparision of the 1993, 2000 and 2006 national surveys*

	ENEC 1993 (n=2256)	ENSA 2000 (n=2311)	ENSANUT 2006 (n=4040)
Cholesterol (mg/dl)	182.7	197.5	198.5
Triglycerides (mg/dl)	213.4	181.7	139.6
HDL cholesterol (mg/dl)	38.3	38.4	39.0
LDL cholesterol (mg/dl)	116.4	122.7	131.5
Cholesterol > 200 mg/dl (%)	27.1	42.4	43.6
Triglycerides >150 mg/dl (%)	42.3	49.1	31.5
HDL cholesterol < 40 mg/dl (%)	61	63	60.5

* Data are presented either as means or percentages
ENEC 1993= National Survey of Chronic Diseases 1993[7]
ENSA 2000= National Health Survey 2000[8]
ENSANUT 2006= National Health and Nutrition Survey 2006[9]

evident for LDL cholesterol. This rising trend carried over to the 2006 survey. The HDL cholesterol levels were not different among the three surveys. The lower plasma triglycerides concentration reported in ENSANUT 2006 is probably explained by an improvement in the quality control applied to the sampling procedures.

Lipid disorders are frequent in Mexican adults. The prevalence of hypercholesterolemia (cholesterol ≥ 200 mg/dl), hypertriglyceridemia (triglycerides ≥150mg/dl) and low HDL cholesterol (< 40 mg/dl) in all three surveys is shown in table II. The most common abnormality was low HDL cholesterol (60.5%, 95% CI 58.2-62.8%). The prevalence of this condition remained remarkably unchanged between surveys probably because it is strongly linked to genetic factors. As expected, men had a higher prevalence of low HDL cholesterol as compared to women (68.1 *vs.* 54.0% respectively, in the 2006 survey).

Hypercholesterolemia was the second most common abnormality. The prevalence of hypercholesterolemia grew from 27.1% in 1993 to 43.6% in 2006. An increment was observed in all age groups, but the extent of the change was significantly greater in young adults (from 13.9 to 34.8% in the age group 20-29 years) compared to older subjects (from 45.2 to 55.2% for the age group 50-59 years). This remarkable change in the prevalence of hypercholesterolemia was observed in both young men (from 17.4 to 33.5% in the age group 20-29 years) and women (from 11.1-36.0%, respectively). This trend contrasts with that seen in the USA, where mean cholesterol levels have been lowered in recent years due to the frequent use of statin therapy.

In ENSANUT 2006, a prior diagnosis of hypercholesterolemia was present in only 8.6% (95%CI 7.2-10.1%) of the population; this percentage was smaller for hypertriglyceridemia (3.8%, 95%C.I. 3.0, 4.9%). These percentages are similar to those reported in ENSA 2000 (6.1% for hypercholesterolemia). Among those with a prior diagnosis of hypercholesterolemia, 71.8% (63.9-78.5%) were receiving treatment. Drug therapy was prescribed in a large proportion of the treated cases with hypercholesterolemia 77.1% (67.8-84.3%).

In 2006, the prevalence of an LDL cholesterol level above 130 mg/dl was 41.4% (37.6-45.3%) for men, 50.0% (46.7-53.3%) for women and 46.0% (43.5-48.6%) overall. The prevalence of a non HDL cholesterol level above 160 mg/dl was 39.1% (35.3-43.0%) in men, and 45.3% (42.0-48.6%) in women and 42.4% (39.9-45.0%) in total. These figures could not be compared with the 2000 data because this information was not included in the report. The percentage of the population with LDL-C levels >130 mg/dl increased from 31.6% in 1993 to 46% in 2006. If we analyze the percentage of the population qualifying for statin therapy based on the NCEP 2004 guidelines, this figure increases from 11.7% of the population in 1993 to 24.19% (95% CI 16.7-28.7%) in 2006. The explanation for this increment is the greater number of individuals with diabetes and other CHD equivalents (10.5% *vs.* 13.8%) and the higher LDL-C levels in the population. The majority of the dyslipidemia cases qualifying for drug treatment had moderate hypercholesterolemia and other coexisting co-morbidities that increased their cardiovascular risk. Two or more risk factors in the absence of a CHD equivalent were found

in 31.5% of the population. Based on the 2006 data, we estimate that nearly twelve million Mexicans should be trained to change their lifestyle. Also, close to eight million individuals require drug therapy to decrease their cardiovascular risk.

Finally, in ENSANUT 2006, 31.5% (95% CI, 29.3-33.9%) of the population had hypertriglyceridemia. This percentage is lower compared with previous surveys. This surprising result may be due to changes in the sampling process between surveys. In 2006, patients were contacted one day prior to the interview and asked to be fasted when the blood sample was scheduled. Interviewers confirmed the fasting conditions of the participants. Most of the blood samples obtained in previous surveys were random samples. Since triglycerides concentrations are strongly influenced by the sampling process, we believe that the additional precautions may have positively influenced the results.

In Mexico, the prevention of cardiovascular disease goes hand in hand with an improvement in plasma lipid levels. This represents an enormous challenge for the authorities and the implementation of effective public health programs is urgently needed.

Trends in arterial hypertension

Arterial hypertension is one of the most important determinants of cardiovascular disease. Its pathogenesis is associated with multiple genetic, dietary and lifestyle factors. The biological determinants include atherosclerosis, hyper-responsiveness to adrenergic stimuli, insulin resistance and endothelial dysfunction,

among others. There is evidence demonstrating that reductions in the prevalence of arterial hypertension the population intervening with appropriate medical therapy, results in a significant reduction in cardiovascular mortality.[32]

Alarmingly, the prevalence of hypertension has increased from 23.8% in 1993[7] to 30.7% in 2000[33] and to 43.2% in 2006.[34] Those increments are equivalent to 1.5 pp/year over the last 13 years. Such a trend had no gender differences: (25.1, 32.6 and 40.3 % for males) and (22.9, 29.0 and 47.3 % for females). Though, prevalence tended to be higher in male than in female. The mean systolic blood pressure decreased non-significantly from 129 in 1993 to 122 mm Hg in 2006. A similar but non significant trend was observed from 83.9 in 1993 to 77.9 mm Hg in 2006 (Table III).

Perhaps the most astonishing finding comes from the 2006 survey, where almost 60% of the cases with arterial hypertension were not previously diagnosed. These figures call for urgent preventive actions to reduce the risk for arterial hypertension. This will help to reduce cardiovascular morbidity and mortality.

Discussion

This report analyses the results of three Mexican population based surveys demonstrating a clear increasing trend in the prevalence in T2D, dyslipidemia and hypertension over a 13 year period (1993-2006). This finding must be considered in the context of a similar trend in the prevalence of overweight and obesity.[35] Obesity as a strong risk factor for, both, T2D and cardiovascular diseases.

Table III

Trends in the prevalence of arterial hypertension in three national probabilistic surveys in Mexican population older than 20 years of age

	ENEC 1993	*ENSA 2000*	*ENSANUT 2006*
Overall hypertension (%)	23.8	30.7	43.2
Male (%)	25.1	32.6	40.3 (95%C.I. 45.9 - 48.8)
Female (%)	22.9	29.0	47.3 (95%C.I. 39.2, 41.4)
Blood pressure (mmHg), (mean (SD)) Systolic	129.6 (17.5)	122.8 (16.7)	122 (95%C.I. 121.6, 122.3)
Diastolic	83.9 (13.2)	80.2 (11.4)	77.9 (95%C.I. 77.7 - 78.2)

ENEC 1993= National Survey of Chronic Diseases 1993[7]
ENSA 2000= National Health Survey 2000[8]
ENSANUT 2006= National Health and Nutrition Survey 2006[9]

A dramatic example are the frequency of T2D vascular complications encountered in subjects over 40 years of age with T2D. In this age group, 15.6% reported to have retinopathy, 14.9% neuropathy, 1.2% myocardial infarction and 1.1% were in a renal dialysis program because of nephropathy.[36] The population estimate for persons over 40 year of age with T2D in Mexico is closely to 5.7 million. If we extrapolate from the figures for T2D complications and the estimated number of subjects with T2D, it will result in an estimate of 889 000 subjects with retinopathy, 849 000 with neuropathy, 68 400 with myocardial infarction and 62 700 in dialysis because of nephropathy. It represent a significant disease burden for the Mexican health services and for the families of the affected subjects.

Most of the increments in the prevalence of T2D, dyslipidemias and hypertension were more noticeable in subjects younger than 40 years of age; nevertheless the age distribution by decades among the three national surveys was not different. Suggesting that these diseases are appearing at earlier ages.

The public expenditure for T2D, cardiovascular disease and obesity has risen in recent years representing 7% of the national expenditure in health. We foresee that this expenditure will be rising further in the near future, because of the rapid aging population and the growing prevalence of overweight/obesity and T2D in Mexico.

The recent consensus to reduce the prevalence of obesity[37] and implement strategies to improve the detection and quality of care for chronic non-transmissible diseases,[38] brings a hope to curb the impact of non-transmissible chronic diseases on the health of the Mexican population. We are convinced that the information presented here help to strengthen public policies aiming to prevent and develop more proficient medical care to reduce this overwhelming epidemic of chronic non-transmissible diseases and to raise the awareness of the public and the medical profession.

Conflicts of interest

We declare that we have no conflicts of interest.

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